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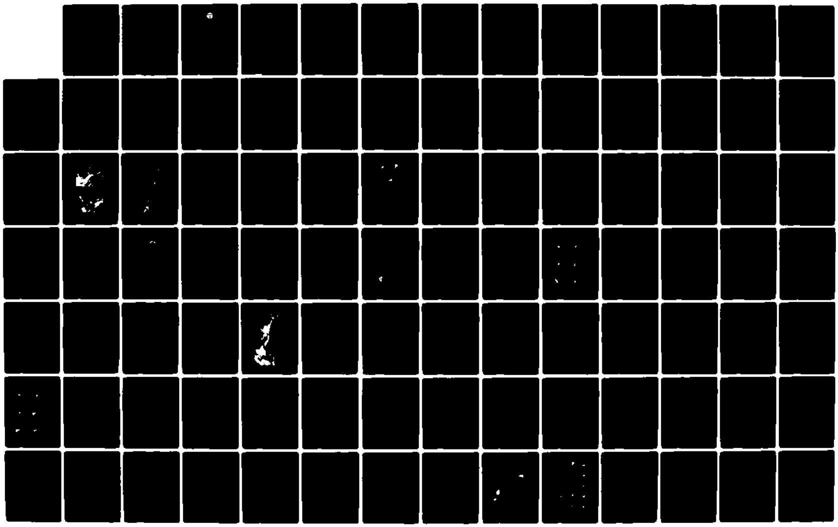

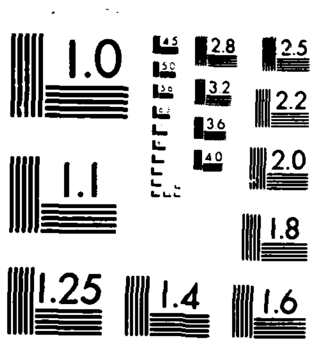
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AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING, EASTERN CHUKCHI AND ALASKAN BEAUFORT SEAS, 1983: WITH A FIVE YEAR REVIEW, 1979-1983

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NOSC, Code 5141

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SEACO, Inc

June 1984

Prepared for
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Aerial surveys and acoustic recordings of bowhead whales and, secondarily, other marine mammals were made from mid-April through May and from mid-July through mid-October 1983 in the northern Bering, eastern Chukchi, and Beaufort Seas. Survey results and observations on bowhead distribution, relative abundance, migration patterns, general behavior, and sound production for spring and fall seasons are presented. Presented here are survey results and observations on grey whale distribution, relative abundance, and general behavior for July. Incidental sightings of all marine mammals are reported.

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EXECUTIVE SUMMARY

This report summarizes the 1983 investigations of the distribution, abundance, migration, and habitats of endangered whales in the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas. Aerial transect and search surveys were flown in a specially modified Grumman Goose (N780) in the study region from mid-April through May and from mid-July through mid-October 1983. Sonobuoys were deployed on most flights to record whale sounds, and occasionally industrial and ambient noise. Overall, 208 sightings of 395 bowhead whales (Balaena mysticetus) were made on 87 flights. During spring, 223 bowheads were seen. Three were seen between St. Lawrence Island and Cape Prince of Wales in late April. The spring migratory route near and east of Point Barrow, centered roughly along 71°30'N, was typical of 1979 to 1982 findings. Belukha whales were observed preceding and following the bowhead migration in spring. In early August, bowheads were observed in the Alaskan Beaufort Sea, north and east of 70°20'N, 141°44'W. These whales maintained headings in all directions and exhibited some social behaviors. In the latter half of September whales were found closer to shore along the north Alaskan coast, and were strongly directed to the west. As in past years, bowhead distribution across the Alaskan Beaufort Sea was centered roughly along the continental shelf break at water depths between 10 m and 500 m. There was no observed peak migration period in fall, although sightings per unit effort (SPUE) were consistently high the last two weeks of September. Thirteen bowhead calves were seen in the fall, and a gross annual recruitment rate (GARR) of 13/172 or 7.5 percent calculated. Observed bowhead behaviors were tabulated, and all recorded sounds were aurally classified and tabulated. Two additional aircraft (N642 and N655MA) were dedicated in the Beaufort Sea from 17 August to 1 October to monitor bowhead behavior near seismic survey operations, and to conduct controlled experiments to study same. Data were supplied daily to these researchers to advise them of bowhead distribution and movements.

One thousand fifty-two gray whales (Eschrichtius robustus) were seen between St. Lawrence Island and Point Barrow from 20 July through 13 October. Ninety-six percent of these whales were seen in the Chirikov Basin between 20 and 30 July. Most of these whales were feeding. Only one gray whale calf was seen in the Chirikov Basin.

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INTRODUCTION

The Naval Ocean Systems Center (NOSC), San Diego, California, has been funded by the Minerals Management Service (MMS), U. S. Department of Interior, since 1979 to conduct aerial surveys of endangered whales and secondarily other marine mammals in the northern Bering (above 62°N latitude), eastern Chukchi and Alaskan Beaufort Seas. As part of its responsibilities under the Outer Continental Shelf Land Act, National Environmental Policy Act, Marine Mammal Protection Act, Endangered Species Act and other legislation, MMS has continued this work as an extension of previous studies (Ljungblad et al, 1980; Ljungblad, 1981; Ljungblad et al, (a) 1982; Ljungblad et al, 1983). It is expected these studies will be useful to MMS in making sound decisions relative to leasing, exploration, and development of the Alaskan Outer Continental Shelf (OCS).

The principal species investigated over the past four years has been the bowhead whale (Balaena mysticetus). Historically, bowheads had a nearly circumpolar distribution north of 60°N latitude. However, a long history of exploitation seriously reduced the number of whales in each of five geographically separate stocks (Breiwick et al, 1981). The western Arctic stock, now estimated to contain 3475 ± 336 whales (Zeh et al, 1983), is the group monitored in this study.

Gray whales (Eschrichtius robustus) have also been studied during this investigation. Principal areas surveyed are the summer feeding grounds in the northern Bering and eastern Chukchi Seas (Bogoslovskaya et al, 1981; Nerini, 1984). This population is now estimated to number 17,577 ± 2,364 whales (Reilly, et al, 1983).

This report is a summary of 1983 field results on regional surveys of bowhead whale distribution, relative abundance, migration, and behavior in accordance with the objectives as outlined below. Gray whale distribution and relative abundance is also reported, as well as incidental information on all other marine mammals seen. Comparison and synthesis of 1983 data with previous years' results are provided in a brief conclusion section at the end of the report. A flight track and descriptive caption for each flight and a seasonal survey of all marine mammal sightings by species are presented in Appendix A. The distribution of 1983 survey effort and observed densities of bowhead and gray whales with comparisons to 1979 through 1982 are presented in Appendix B.

Objectives

The overall objectives of our study during 1983 were to:

1. Determine the distribution, migratory timing and path width, relative abundance, and habitats of bowhead whales in the northern Bering, Chukchi, and Beaufort Seas

2. Derive estimates and indicators of relative and/or absolute abundance of endangered whales in or near existing or proposed federal lease areas, in the northern Bering, Chukchi, and Beaufort Seas

3. Utilize such estimator/indicators to describe spatial and temporal patterns of bowhead whale distribution as appropriate

4. Describe behavioral characteristics of bowhead whales as observed during their migration

5. Obtain and analyze recordings of bowhead whale sounds

6. Obtain distributional information on non-endangered marine mammals incidental to other investigations

Specific additional objectives during October were to:

1. Survey the Barrow Arch proposed federal oil lease area (sale 85) from 68°N to 73°N and from the Alaskan coast west to the International Date Line (168° 58'W)

2. Determine when the last bowhead whales left the Beaufort Sea

3. Define movements of whales and other marine mammals through the Bering Strait

In conjunction with our survey objectives two additional research teams and aircraft were dedicated in the Beaufort Sea for the period 17 August through 1 October to:

1. Conduct controlled bowhead whale - seismographic exploration experiments in cooperation with active geophysical vessels

2. Obtain and analyze recordings of bowhead sounds and seismographic exploration boat sounds

3. Monitor seismic activities and bowhead behaviors to assess possible disturbance caused by seismographic exploration and related activities

Thus, correlated objectives, specific to the fall season, were to provide daily reports on the distribution, behavior, movement, habitat, and reactions of bowheads to geophysical boats as well as a summary of survey efforts and conditions. Reports were sent to the government officials regulating seasonal

offshore drilling and geophysical exploration, i.e., Minerals Management Service (MMS) and National Marine Fisheries Service (NMFS), and to the aforementioned research teams monitoring the interaction between the bowhead whales and the geophysical boats. The geophysical companies received reports by radio from the aircraft when whales were sighted in their area, and at the end of each day's survey. The reader is directed to Ljungblad et al, (1984, in preparation) for a complete report of results on the bowhead whale - seismographic exploration experiments and monitoring effort.

METHODS AND MATERIALS

Study Area and Aerial Surveys

The overall survey area included the Bering Sea north of St. Lawrence Island, the Chukchi Sea east of the International Date Line (IDL), and the Beaufort Sea from Point Barrow to 140°W longitude offshore to 72°N latitude. This survey area was divided into blocks (Figure 1) suitable to line transect surveys, (i.e., one, or with favorable conditions, two blocks could be surveyed completely on one flight). Survey blocks in the Bering Sea retained identifying letters assigned them in 1981 (Ljungblad et al, (a)1982), so that they could be easily referenced back to earlier work. All other blocks were consecutively numbered.

Two types of aerial surveys were utilized to accomplish the objectives listed:

1. **Line transect surveys** were flown in survey blocks to determine distribution and estimate relative and absolute abundance. Coverage of no less than 10 percent of the total area of each block was planned. Line transect is one available survey method from which statistical inferences can be made, provided the starting and turning points of the line are selected randomly (Cochran, 1963). Survey blocks were divided into sections that were 18.5 km wide, and each section marked at top and bottom with 10 equally spaced ticks. Starting and/or turning points were chosen within each section by selecting two numbers between 1 and 10 from a random numbers table and matching them to the numbered ticks. The transect line was then drawn between these two points. The same procedure was followed for each section of the survey block, then all transect lines were linked together with short connecting lines at top and bottom.
2. **Search surveys** were flown into areas of maximum probability of sighting bowheads and did not follow a preset paradigm. The exact routes of search surveys were dependent upon previous patterns of whales sightings (i.e., number, heading, swimming speed), weather, sea state, and ice conditions. Search surveys were flown to locate whales, observe their behavior, follow migrating groups or individuals, and record water-borne sounds.

The year was divided into three seasons: spring (April, May), summer (July) and fall (August, September, October). The bases of operation were Nome, Point Barrow, and Deadhorse.

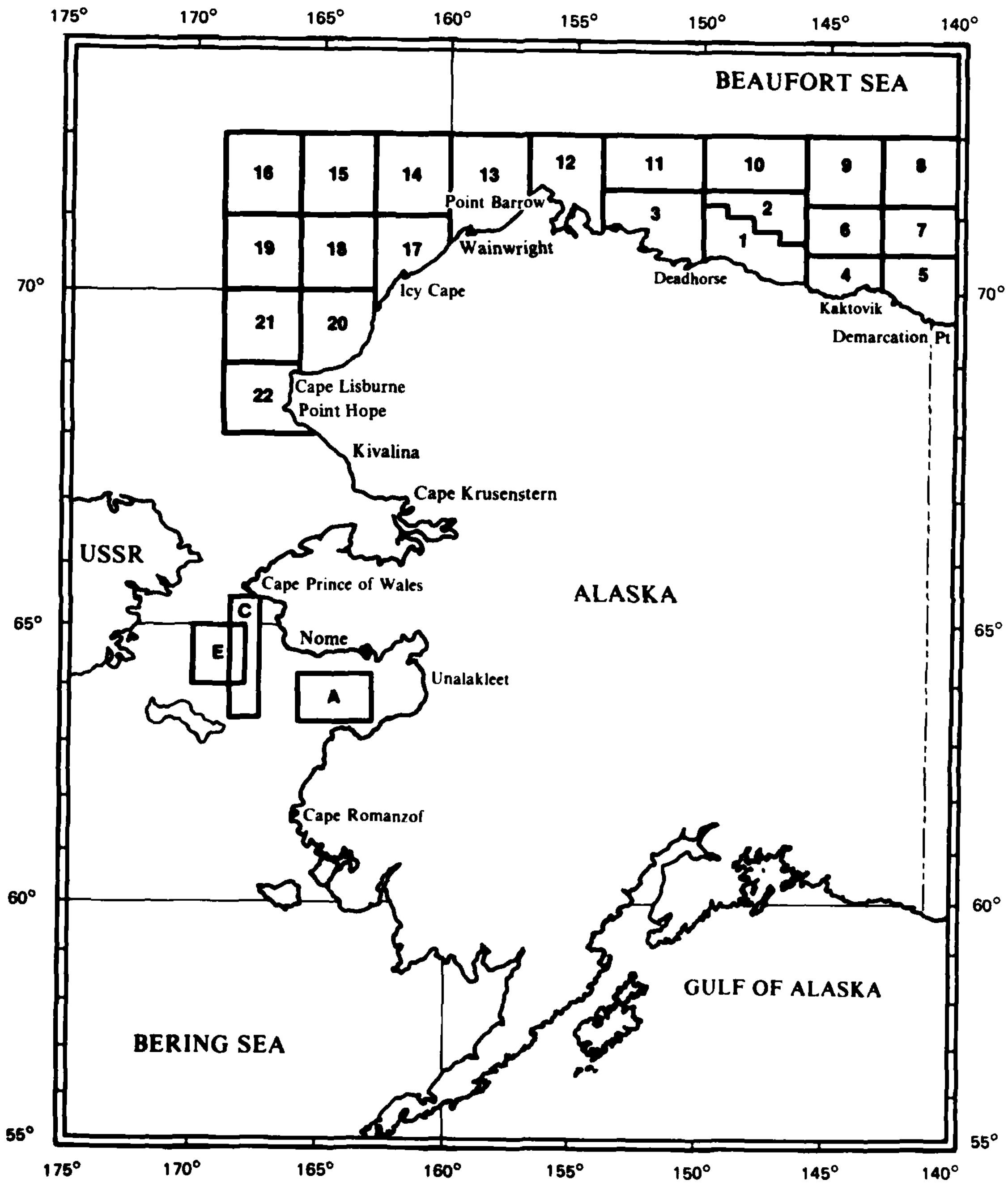


Figure 1. Overall survey area and survey blocks.

Equipment, Data Collection and Analyses

The aircraft used for the surveys was a Grumman Turbo Goose (G21G) provided by the Office of Aircraft Services, Department of Interior, Anchorage. The aircraft was equipped with a Global Navigation System (GNS) 500, which has 0.37 km/h precision. The GNS provided continuous position updating and transect turning point programming. Surveys were planned to be flown at 305 m and 51 percent of the flight time was within 30 m of this target altitude. However, weather forced the aircraft to altitudes between 137 and 275 m 31 percent of the time, and as low as 30 m on one survey (12 minutes total). Sixteen flights (18 percent of the time) were flown as high as 458 m during clear weather to maximize visibility. Airspeed varied between 222 and 296 km/h. The aircraft's maximum range was 7.5 h.

Observers were positioned so that the observer navigating was in the co-pilot's seat; the data recorder was in the left-rear seat, and an observer was in the right-rear seat. The four seats in the cockpit had large side windows affording good visibility to all observers. The pilots and all observers were connected to a common communication system. The pilots acted as limited observers. Each observer was provided with a clinometer.

A portable computing system (Hewlett-Packard 85) was used to store and later analyze the flight data. The computer was interfaced to the GNS 500 for automatic input of entry number, time, latitude, and longitude, and to the radar altimeter for precise input of altitude. One of three different data entry formats was selected on the computer depending on the reason for entry. Whenever possible, a 29 key entry format was used when whales were seen (Table 1). If there were many whale sightings within a short period of time an abbreviated 19-key format was used. A position update 15-key format, including data on weather, visibility, ice coverage, and sea state was entered at turning points or, in the absence of sighting data, every 10 minutes. Sea state and ice coverage were recorded according to the Beaufort scale outlined in Chapman (1971), and aerial ice reconnaissance and ice terminology as presented in the Naval Hydrographic Observers Manual (H. O. Pub. No 609, H. O. Misc. 15603), respectively.

During the fall season an on-site computing system was established at the Deadhorse field station. The system consisted of a microcomputer and four peripherals: a dual diskette drive, printer/plotter, printer and phone modem. This system was a vehicle for a data quality check and survey track mapping

Table 1. Data entry sequence on the Hewlett Packard 85 computer. The full 29-key and abbreviated 19-key and 15-key entry formats are delineated by flow chart lines.

1.	Entry number
2.	Time (GMT)
3.	Latitude
4.	Longitude
5.	Altitude (ft)
6.	Reason for entry
7.	Survey type (flag)
8.	Weather
9.	Vision right (km)
10.	Vision left (km)
11.	Ice coverage (tenths)
12.	Ice type
13.	Beaufort sea state
14.	Water color
15.	Water depth (fathoms)
16.	Species
17.	Clinometer angle
18.	Sighting cue
19.	Behavior
20.	Total number
21.	Est. adult size (ft)
22.	Total number calves
23.	Est. calf size (ft)
24.	Swim direction (°M)
25.	Est. swim speed (kns)
26.	Aircraft response
27.	Repeat sighting
28.	Photo roll number
29.	Photo frame numbers

19-key

15-key

immediately after each day's flight. Once the flight track and sighting data were verified they were formated on the microcomputer for transfer, via phone modem, to the Arctic Environmental Information and Data Center (AEIDC) office in Anchorage. A text summary of the area surveyed and conditions encountered was also sent via modem to Anchorage on a daily basis. This system provided an efficient means to review and check data while in the field, as well as to provide an immediate flow of information to regulatory officials (MMS and NMFS) in Anchorage. Such "real-time" data processing enhances decision making at all levels of field operations.

Sonobuoys, passive acoustic listening systems containing hydrophone arrays, and VHF transmitters, were dropped near whales whenever possible. Models AN/SSQ-57A, AN/SSQ-41B or AN/SSQ-41A with a frequency response of 10 Hz to 20 kHz, 10 Hz to 20 kHz, and 10 Hz to 6 kHz, respectively, were used. Sonobuoys are designed to be dropped from the aircraft, their descent slowed by means of a rotochute or parachute. Once in contact with water, the unit is energized by a saltwater-activated battery. At that time the parachute assembly is jettisoned and the hydrophone array dropped to a preselected depth of 18.2 or 91.4 m (60 or 300 ft). The 18.2 m depth setting is most commonly used. The sounds picked up by the hydrophones are then amplified and transmitted to a VHF broad band receiver aboard the aircraft. This output is coupled to a Nagra IV SJ recorder with a frequency response of 25 kHz to 10 kHz $\pm$ 2 dB at a recording speed of 9.5 cm/s. This recorder has two channels permitting simultaneous recording of water-borne sounds and verbal comments.

Attempts were made to photograph as many bowhead whales as possible. Still photographs were made with hand-held 35 mm cameras (Olympus OM-1) with 210 mm and 230 mm lenses using ASA 64 and ASA 200 film at 1,000th or 1-500th of a second shutter speed. The altitude of the aircraft and the photograph roll and frame number were noted and stored on the computer.

Bowhead, gray, and belukha whale distribution was plotted by month and season. Relative abundance and absolute density were derived as sightings per unit effort (SPUE = 1 hr. survey)/block and strip transect/region (See Appendix B), respectively. Migration timing was analysed as SPUE/date. Multiple regression and correlation analysis were performed on data sets to assess relatedness (Zar, 1974). Directionality of whale headings was analyzed using Rayleigh's and Chi square tests (Batschelet, 1972).

Operational Definitions of Observed Bowhead Whale Behaviors

Bowhead behaviors were classified by means of operational definitions (Table 2). Behaviors were catalogued into two types for purposes of discussion: migratory behaviors, which included swimming and diving; and social behaviors (typically observed in groups) such as milling, feeding, mating, calf nurturing, resting, and displaying. Displays included breaches, spy-hops, tail and flipper-slaps, rolls, and underwater blows. Swimming speed was subjectively estimated by observing the time it took a whale to swim one body length. An observed swimming rate of one body length/minute corresponded to an estimated speed of 1 km/h (0.5 kn); one body length/30s was estimated at 2 km/h, and so on.

Any time a sudden overt change in whale behavior was observed coincident with the arrival of the survey aircraft it was recorded as "response to aircraft," although the specific stimulus for the behavioral change was impossible to determine with certainty. Such changes included abrupt dives, course diversion, or cessation of behavior ongoing at first sighting.

Table 2. Operational definitions of observed bowhead whale behaviors.

	Behavior	Operational Definitions
MIGRATORY	**Swimming**	Forward movement through the water propelled by tail pushes; performed individually or as part of a group.
	Diving	Change of swimming direction or body orientation relative to the water surface resulting in submergence; may or may not be accompanied by lifting of the tail out of the water; performed individually or as part of a group.
SOCIAL	**Milling**	Whale/whales swimming slowly around one another in close proximity (<100 m) at the water surface.
	Feeding	Whale/whales diving repetitively in cloudy water often accompanied by mud streaming from the mouth and defecation upon surfacing (Wursig et al, 1982); nearly synchronous diving and surfacing has been noted as has echelon formation surface feeding with swaths of clearer water noted behind the whales, and open mouth surface swimming.
	Mating	Ventral-ventral orientation of a pair of whales often with at least one other whale present to stabilize the mating couple; often within a group of milling whales; pairs appear to hold each other with their pectoral flippers and may entwine their tails.
	Nurturing (Cow-Calf)	Calf nursing; proximal swimming to an adult; adults coalescing around a cow-calf pair.
	Resting	Single or group of whale(s) at the surface with head, or head and back exposed, showing no movement; more commonly observed in heavy ice conditions than in open water.
	Displaying:	
	Rolling	Whale rotating on longitudinal axis, sometimes associated with mating.
	Flipper-Slapping	Whale on its side striking the water surface with its pectoral flipper one or many times; usually seen in groups, often when slapping whale is touching another whale.
	Tail Slapping	Whale hanging vertically in the water head down with tail out of water and waving back and forth striking the water surface; usually seen in groups.
	Spy Hopping	Whale rising vertically from the water such that the head and up to one third of the body including the eye is exposed; usually seen in groups.
	Breaching	Whale exiting vertically from the water such that half to nearly all of the body is exposed, then falling back into the water, usually on its side, creating a large splash, and presumably some sounds.
	Underwater Blow	Exhalation of breath while submerged.

RESULTS AND DISCUSSION

Spring (April, May) 1983

Survey Effort, Rationale and Sighting Summary

Seventy-four survey hours were flown in the spring with 9 percent (6.5 h) of this effort in the northern Bering Sea, 7 percent (5.5 h) in the Chukchi Sea and 84 percent (62 h) in the Beaufort Sea (Table 3). Initial search surveys (Appendix A: Flights 1 and 2) were flown in the northern Bering Sea and Bering Strait area to assess bowhead whale distribution and behavior there. Coastal search surveys (Appendix A: Flights 3 and 15), conducted in the Chukchi Sea, were designed to assess bowhead whale distribution and behavior along their spring migratory route. Line transect and search surveys were flown in the Beaufort Sea through mid-May to assess bowhead whale distribution, migratory timing and path width, relative abundance, and behavior. Search and transect surveys were generally conducted east of 156°W in block 12 to avoid disturbance to native whaling. On 2 May failure of the GNS disallowed transect survey, so all effort on that date was dedicated to search survey. Search surveys were conducted as far east as 138°W (Appendix A: Flights 14 and 16) in the Canadian Beaufort Sea in an effort to find bowhead whales near the eastern end of their spring migratory route. Except for ice tracks thought to be made by bowheads breaking through grease ice (Ljungblad et al, 1983) seen near 71°40'N, 138°30'W (Appendix A: Flight 14) these flights were largely uneventful.

R. Dronenberg* (North Slope Borough, Barrow, Alaska) requested and MMS approved aerial surveys to be conducted due north of the ice-based bowhead whale census camps. To accomplish this, modified transect lines were flown north of the camp's original position (71°27.2'N, 156°16.8'W) on 3, 4, and 6 May. The nearshore lead in the Chukchi Sea south to Icy Cape and return was searched, also at the request of ice camp personnel, in conjunction with a planned Beaufort Sea search survey on 10 May. This effort was designed in an attempt to coordinate aerial and ground sightings of bowhead whales. Twenty-one data points (Time/Coordinates), representing 36 bowhead whales, resulted from this effort and these data were forwarded to ice camp personnel for possible correlation with their data (Table 4). The ice camps were moved on 4 May due to shifting and possible dangerous ice

*R. Dronenberg, North Slope Borough, Barrow, AK 99723

Table 3. Survey effort and sighting summary,* spring 1983.

Flt	Date	Survey Effort	Bowhead Whale	Belukha Whale	Bearded Seal	Ringed Seal	Unknown Pinniped	Walrus	Polar Bear	Comment
1	4/21	Search: St. Lawrence Island to Bering Strait	1/1	2/36	12/28	3/4	7/10	2/4	0	1 ribbon seal - many pinniped too far away for positive ID
2	4/24	Search: St. Lawrence Island to Bering Strait	1/2	6/402	9/10	0	0	12/111	2/4	350 belukha stationary
3	4/25	Search: Coastal Leads Nome - Barrow	7/17	4/96	4/5	4/6	1/1	1/3	2/5	mating (1 pair)
4	4/28	Search: 12 Transect: 12,11	5/8	0	2/2	7/7	0	0	0	lone whale breaches
5	4/29	Search: 12,11,3,1, Transect: 2,10	10/19	0	1/1	0	0	0	0	1 mottled, mating (1 pair)
6	4/30	Search: 11,3 Transect: 12,11,3	8/18	2/31	0	0	0	0	0	1 mottled, mating (1 pair)
7	5/1	Search: 11,12,1 Transect: 2,9,10	11/34	0	0	0	0	0	0	1 mottled, matings (4 pair) possible cow-juvenile
8	5/2	Search: 11,12,3,1 Transect: NO GNS	15/53	3/27	0	0	0	0	0	2 mottled, matings (3 pair)
9	5/3	Search: 12 Transect: 11,3,12	6/15	18/285	0	0	0	0	0	mating (1 pair)
10	5/4	Search 12,11 Transect: 11,10	13/31	13/245	0	0	0	0	0	1 mottled, mating (1 pair)
11	5/5	Search: 11 Transect: 12,11	1/1	6/87	0	0	0	0	0	
12	5/6	Search: 12,10,2,1 Transect: 11	2/2	3/43	0	0	0	0	0	fogged out of 10
13	5/8	Search: 1,2,6,7,4 Transect: 9,8	0	0	0	1/1	0	0	0	97-100% ice throughout
14	5/9	Search: To 138°W, CAN Transect: 8	0	0	3/4	2/2	0	0	0	bowhead ice tracks (71°40'N, 138°30"W)
15	5/10	Search: Deadhorse - Icy Cape	12/22	12/145	2/2	3/4	0	0	0	9 mottled, mating (1 pair) possible cow-juvenile
16	5/11	Search: 6,7 to 138°30'W CAN	0	0	1/2	0	1/1	0	0	90-100% ice throughout
		TOTAL	92/223	69/1397	34/54	20/24	9/12	15/118	4/9	

*In the species columns, the numbers represent number of sightings/number of individuals.

Table 4. Bowhead sightings west of 155°50'W longitude between 28 April and 10 May 1983 - forwarded to ice-based census personnel on 19 May 1983 for possible correlation with their sighting data.

Date	Number Bowheads	Time (GMT)	Latitude	Longitude	Est. Hdg. (°M)	Comment
28 Apr	1	21:45'36"	71°32.5'	155°50.0'	070	
30 Apr	2	19:11'18"	71°26.2'	156°41.5'	060	
30 Apr	2	19:45'00"	71°30.2'	155°52.0'	060	
1 May	3	21:50'48"	71°34.5'	155°50.9'	-	
1 May	4	21:59'18"	71°34.8'	155°52.0'	-	2 pair mating
3 May	1	22:40'42"	71°28.6'	156°14.4'	030	
3 May	2	23:11'42"	71°30.4'	156°03.7'	070	
3 May	2	03:12'12"	71°30.4'	155°53.1'	090	
4 May	1	00:55'06"	71°31.5'	156°05.4'	-	
4 May	2	01:10'18"	71°29.8'	156°13.9'	030	
5 May	1	00:04'12"	71°30.0'	156°08.1'	030	
6 May	1	19:08'06"	71°30.7'	156°15.6'	300	large white tail chevron
10 May	1	21:51'48"	70°19.6'	162°26.5'	050	
10 May	1	21:57'48"	70°27.5'	162°10.4'	150	
10 May	1	22:01'00"	70°30.0'	162°06.8'	030	
10 May	1	22:04'30"	70°33.1'	161°52.1'	050	
10 May	2	22:58'42"	71°22.4'	156°38.6'	030	28 km northwest of camp
10 May	1	23:02'30"	71°25.4'	156°29.1'	-	28 km northwest of camp
10 May	1	23:07'12"	71°29.9'	156°02.6'	-	
10 May	4	23:11'12"	71°31.1'	155°57.3'	060	cow-juvenile both mottled
10 May	2	23:20'30"	71°31.8'	155°56.8'	060	large white tail chevron

conditions at their original site. Thus, aerial and shorebased sighting correlation may be low.

Search and transect survey distance flown was estimated and correlated with the number of bowheads seen (Table 5). Short transect survey lines were flown in blocks 2 and 3 north of 71°10'N where ice coverage was approximately 95 percent. A comparison can be made in the Beaufort Sea between western blocks 11 and 12, versus eastern blocks 9 and 10 where a survey of 8408 km resulted in 189 sightings, and a survey of 3763 km resulted in 10 sightings, respectively.

The two search surveys made in the northern Bering Sea during 1983 spring represent much less effort than was expended in that area during each of the three previous years. Large concentrations of bowhead whales were seen north of St. Lawrence Island and through the Bering Strait in 1980 and 1981. No such concentrations were found in 1982 nor 1983. It appears that the timing and extent of bowhead aggregations between St. Lawrence Island and the Bering Strait in spring may be quite variable.

The two coastal search surveys made in the Chukchi Sea represent an effort comparable to past years. Ice conditions were very similar to those encountered in previous springs with no well defined lead system from the Bering Strait to Point Hope, and a nearshore lead dominating coastal ice conditions between Point Hope and Point Barrow. All bowheads seen in the Chukchi were in or near this lead north of Point Hope. This too is very similar to past years.

Though the 13 line transect and search surveys made in the Beaufort Sea were conducted over a somewhat shortened time frame (28 April to 11 May), the number of flights is comparable to, or exceeds the number made in previous years. More effort was directed toward flying line transect surveys in the Beaufort Sea in 1983 than in past years when greater effort was directed toward conducting search surveys of relatively open water areas. Line transect surveys resulted in greater survey effort over a broader segment of the study area and enhanced ice condition assessment to 72°N latitude. This survey effort possibly resulted in fewer whales seen east of Harrison Bay as transect lines did not always coincide with the scant open water extant there.

Table 5. Estimated line transect and search survey distances flown with bowhead sightings and comments on ice coverage, spring 1983.

	Search Survey (km)	Transect Survey (km)	Total (km)	Number of Bowheads	Number of Bowheads (km)	Ice Conditions
N. Bering Sea	1808	-	1808	3	0.002	8/10 to 9/10 ice
Chukchi Sea	1530	-	1530	21	0.01	9/10 ice with lead
Beaufort Sea:						
Block 1	779	-	779	-	-	100% ice
Block 2	389	723	1112	-	-	100% ice south 71°10'N 95% to north
Block 3	649	463	1112	-	-	100% ice south 71°10'N 95% to north
Block 4	222	-	222	-	-	100% ice
Block 5	148	-	148	-	-	100% ice
Block 6	371	-	371	-	-	95-100% ice
Block 7	371	-	371	-	-	95-100% ice
Block 8	93	834	927	-	-	95-100% ice
Block 9	148	1112	1260	-	-	95-100% ice
Block 10	371	2132	2503	10	0.004	95% ice
Block 11	1780	2688	4468	85	0.02	90-95% ice
Block 12	1993	1947	3940	104	0.03	9/10 ice with lead
TOTAL	10,652	9,899	20,551	223	0.01	

Survey Conditions Summary

Ice conditions in the northern Bering Sea consisted of 8/10 to 9/10 coverage of broken floe and new ice. Areas of open water changed daily with wind conditions. Satellite photos show the northern Bering Sea was relatively ice free on 26 March (Figure 2A), yet on 22 April (Figure 2B) broken floe and new ice again covered the area resulting in the conditions encountered on our initial surveys. The exception to the heavy ice coverage was an approximate 3 km-wide open water area (oriented east to west) that began approximately 50 km north of Gambell, St. Lawrence Island. This open water area stretched east to the horizon across the International Date Line (IDL), thus we were unable to survey its entire area.

The Chukchi Sea had 9/10 coverage of broken floe and new ice between the Bering Strait and Point Hope, with a predominantly open water nearshore lead extending from Point Hope to Point Barrow (Figure 2). On 25 April this lead was approximately 1 km wide between Point Hope and Wainwright, narrowing to about 0.5 km near Point Barrow.

Ice conditions in the Beaufort Sea changed little during our field season with coverage varying between 8/10 to 10/10 over all areas surveyed (Figure 3). The nearshore lead off Barrow was open (to approximately 3 km) through 2 May, but by 3-4 May winds had blown in large pieces of broken floe and pan ice that closed off this lead. When the lead was open it extended east to 154°40'W where a distinct lead system gave way to predominately 8/10 to 9/10 coverage between 154°40'W and 152°W. Ice coverage between 152°W and 143°W (between 71°10'N and 72°N) averaged over 9/10 (95 percent), with most open water areas comprised of discontinuous north-south running cracks. East of 143°W ice conditions were somewhat lighter than those in the central Beaufort Sea, with wider and more numerous cracks and open water ponds. There was no distinct east to west lead system apparent, though discontinuous cracks ran in all directions.

Solid shore fast ice extended roughly to 71°10'N latitude and completely covered the Joint State-Federal Lease Area (block 1) and all but the northern extreme (approximately 52 km^2) of the Federal Lease Sale 71 Area (block 3). On 5 May an extension of a transect leg in survey block 11 (Appendix A: Flight 11) was made to assess ice conditions north to 72°30'N at 153°30'W . Ice conditions there were essentially identical (9/10 broken floe) to those encountered east of 153°W and north of the shorefast ice.

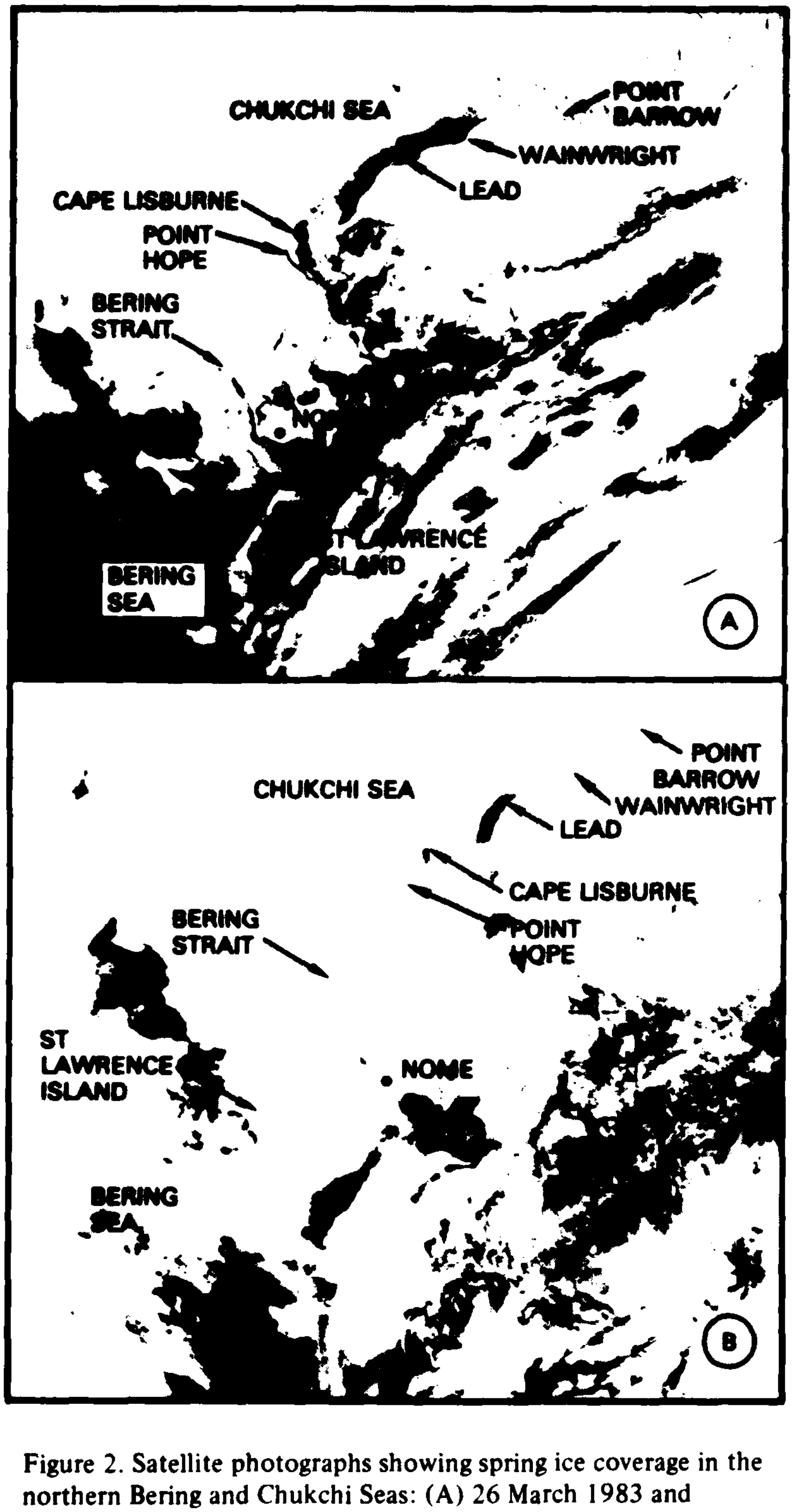


Figure 2. Satellite photographs showing spring ice coverage in the northern Bering and Chukchi Seas: (A) 26 March 1983 and (B) 22 April 1983.

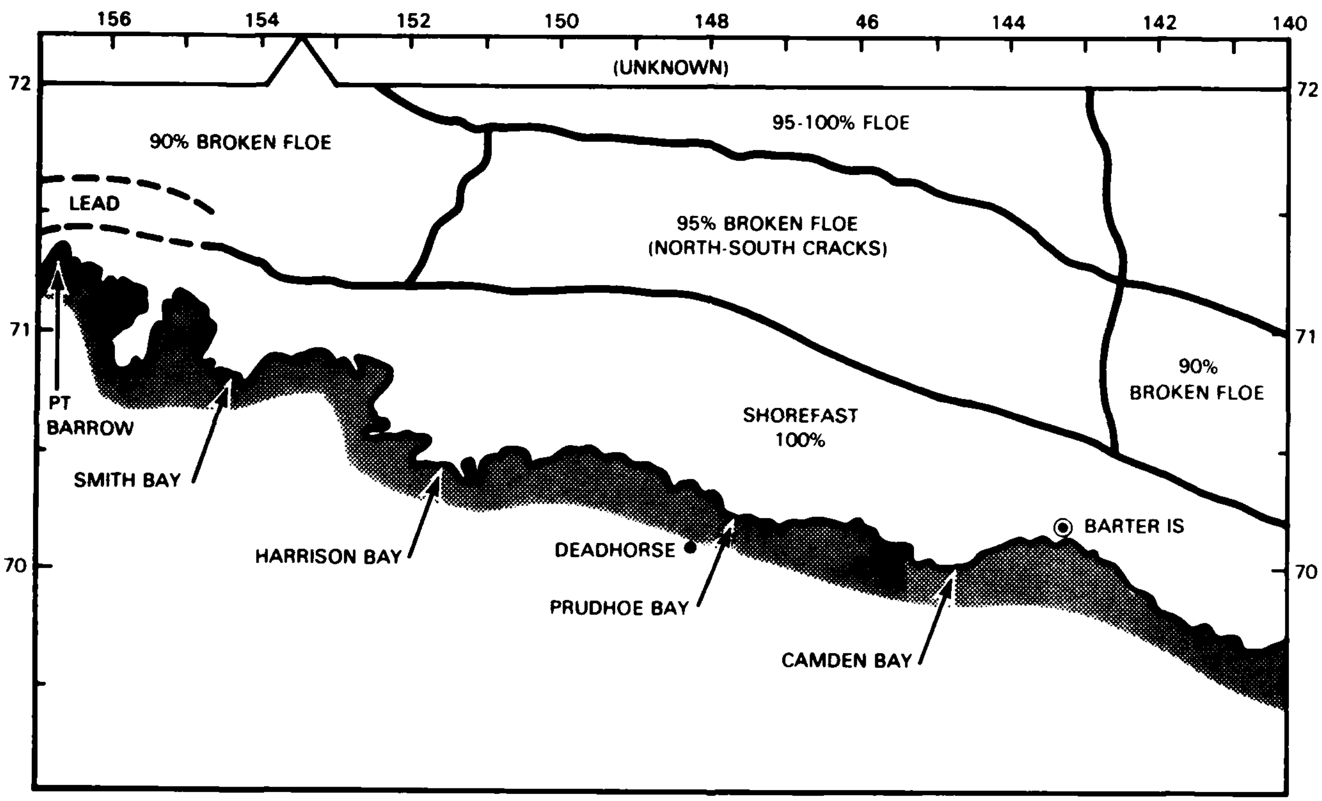


Figure 3. Schematic presentation of Beaufort Sea ice conditions, 28 April – 11 May 1983.

Sea state in open water areas ranged from a Beaufort 00 to 04. As described above, heavy ice conditions predominated in the Beaufort Sea and served to hold down sea state even though 30 to 35 kn winds were common. The average sea state in ice was Beaufort 01. Beaufort 03 to 04 conditions were encountered only in large (1 km) open water ponds and leads.

BOWHEAD WHALE (Balaena mysticetus)

Distribution and Relative Abundance

Ninety-two sightings of 223 bowheads were made in spring 1983 (Figure 4). Three bowheads were seen in the northern Bering Sea-Bering Strait area. Bad weather restricted the survey effort to only two search flights in the area between St. Lawrence Island and Cape Prince of Wales where large numbers of bowheads had been seen during the spring(s) of 1980 and 1981 (Ljungblad 1981, Ljungblad, et al., (a)1982). Few whales were seen in this area in 1983 possibly because: (a) the early March ice break up previously discussed allowed whales to move north then, (b) the possibility that spring bowhead concentrations in the northern Bering Sea are highly variable or (c) the timing of our surveys that were initiated approximately 10 days later than in previous years.

Seventeen bowheads were seen in the Chukchi Sea on the coastal search survey of 25 April. These whales were found in the nearshore lead between Point Hope and Point Barrow. Notably there were no bowhead sightings on the search leg across the southern Chukchi Sea from the Bering Strait to Point Hope. Four bowheads were seen near Icy Cape on 10 May moving northeast near the 20 m isobath.

One hundred ninety-nine bowheads were seen in the Beaufort Sea from Point Barrow to approximately 165 km northeast of Deadhorse (71°40'N, 147°10'W). Most whales were seen just northeast of Point Barrow in survey blocks 12 and 11. Sightings were clustered between 71°30'N and 71°40'N from 156°30'W to 153°00'W. Further east (to 149°30'W) sightings were clustered between 71°20'N and 71°30'N. This distribution of easterly migrating bowheads along the 71°30'N line was very similar to the distribution found in previous years (Ljungblad, 1981; Ljungblad et al., (a)1982).

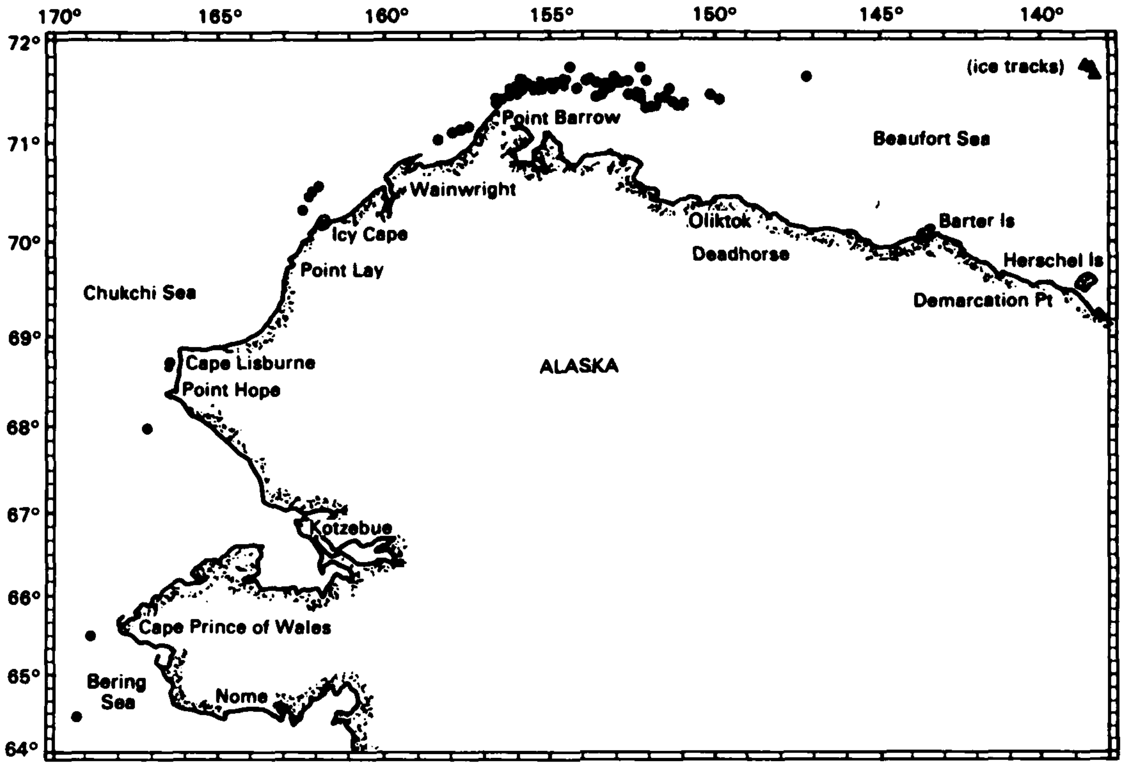


Figure 4. Distribution of 92 sightings representing 223 bowheads, spring 1983.

The relative abundance of bowheads in the northern Bering and Chukchi Seas and in each of the Beaufort Sea survey blocks was derived as the sightings per unit effort (SPUE)/block (Figure 5). This method provides an index to relative abundance and is not a method of population estimation. A calculation of observed bowhead density throughout the survey area with a comparison to previous years is provided in Appendix B. The highest SPUE was calculated in block 12, corresponding with the location of the nearshore lead northeast of Point Barrow. As the whales moved east they were found, with increasing difficulty (i.e., greater survey effort), in block 11 and 10. Heavy ice coverage east of 152°W may have resulted in a lower sighting/survey effort ratio.

Migration Timing and Habitat Relationships

Three bowheads were seen south of the Bering Strait and 17 were seen from Cape Lisburne to Point Barrow between 21 April and 25 April (Appendix A: Flight 1 - 3), indicating that the bowhead spring migration was underway at that

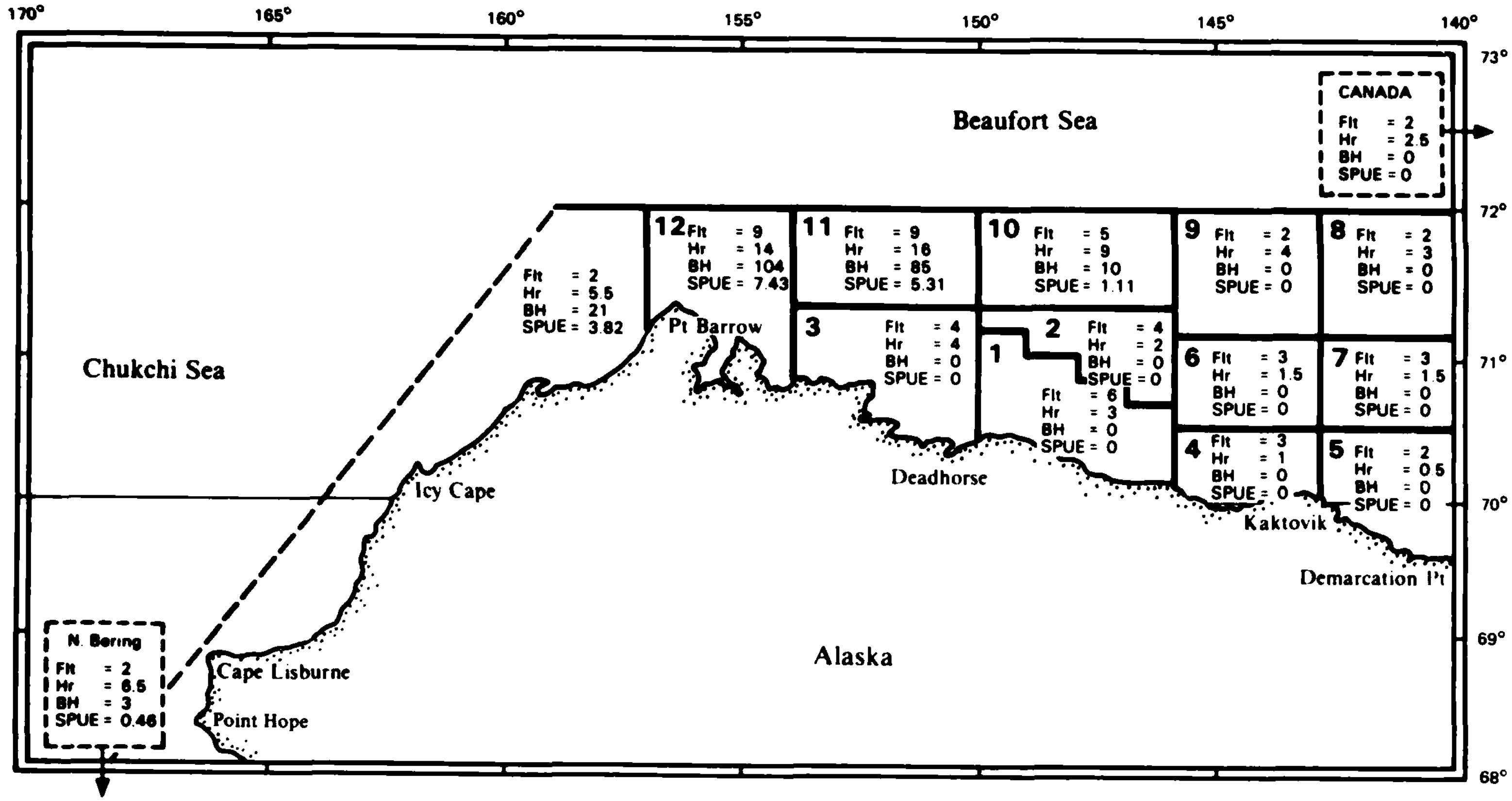


Figure 5. Relative abundance of bowheads in the northern Bering and Chukchi Seas, and each Beaufort Sea survey block as calculated by sightings per unit effort (SPUE). Number of flights (Flt.) in'icate number of times any flight surveyed any part of the area.

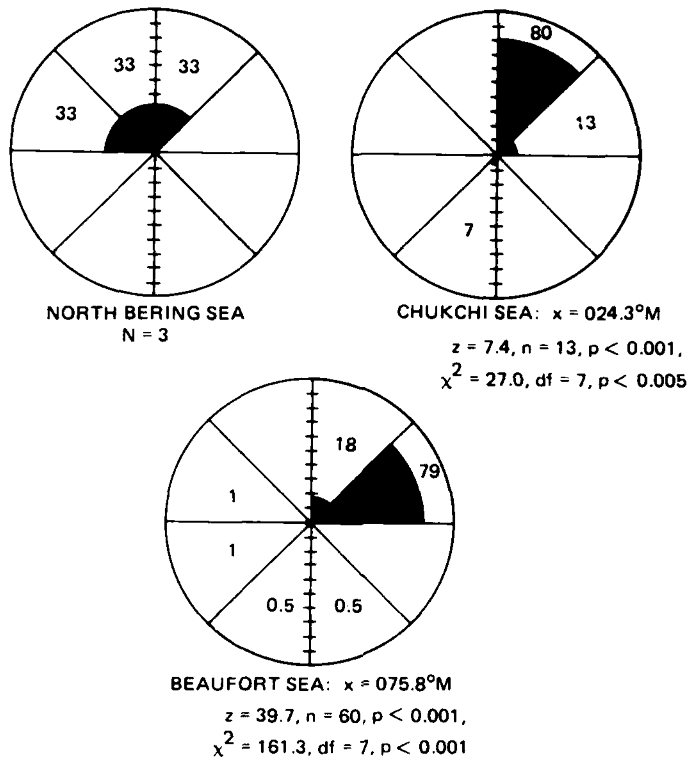


Figure 6. Direction of bowheads in the northern Bering, Chukchi and Beaufort Seas, spring 1983. Numbers within the pie diagrams are percentages.

time. On 24 April, ice based census camp personnel reported 10 to 20 whales/hour passing Point Barrow. On 10 May bowheads were seen passing east of Point Barrow and four were seen swimming along the coastline near Icy Cape in the Chukchi Sea indicating the migration was still in progress.

As expected, the whales were highly directional during the migration period (Figure 6). Bowheads in the Chukchi Sea held a mean heading of 024.3°M with significant clustering about the mean ($z=7.37$, $p<0.001$, $n=13$), a course that takes them roughly along the coastal nearshore lead that extended from Point Hope to Point Barrow. After rounding Point Barrow, bowheads headed east on a mean heading of 075.8°M with significant clustering about this mean ($z=39.7$, $p<0.001$, $n=60$). The mean estimated swimming speed in the Chukchi Sea was 3.2 km/h, and in the Beaufort Sea 3.7km/h.

Fewer whales were seen in the northern Bering Sea this year compared to 1980 and 1981. Timing of the surveys may be an important factor in finding whales there. From 28 April to 15 May 1980, 378 bowheads were seen between St. Lawrence Island and the Bering Strait, with most sightings near the Bering Strait (Ljungblad, 1981). From 5 April to 24 April 1981, 926 bowheads were seen between St. Lawrence Island and the Bering Strait, with most sightings occurring approximately 50 km north of St. Lawrence Island (Ljungblad et al, (a)1982). Surveys in the northern Bering Sea this spring were conducted from 21 April to 25 April or just prior to those in 1980, and after the peak 1981 survey period. Though it is not practical to directly compare years day by day due to variable ice and weather conditions, it may be useful in establishing a likely time period in which large concentrations of bowhead whales may be found south of the Bering Strait.

All bowheads seen in the Chukchi Sea were found in the nearshore lead extending from Point Hope to Point Barrow. None were seen between the Bering Strait and Point Hope in the open water cracks that existed. Three possibilities explaining the confinement of bowhead sightings in the Chukchi Sea to the nearshore lead are, (a) heavy ice conditions in the southeastern Chukchi may preclude seeing whales on any one flight through the area, (b) once the nearshore lead is encountered at Point Hope, the survey follows it to determine distribution in the lead or (c) bowheads in the southern Chukchi Sea may be swimming west of the International Date Line (IDL) out of range of our surveys. Further search or transect surveys in the Chukchi Sea over the nearshore lead are impractical if native hunting is to remain completely undisturbed. Generally spring survey effort has been focused on the Beaufort Sea to monitor ice conditions in OCS lease areas, and to define bowhead migration timing and route through this area. Hence, assessment of bowhead distribution in the Chukchi Sea is somewhat constrained by when and where surveys are flown in spring.

The portion of the migration past Point Barrow that we observed appeared to be pulse-like as described by SPUE/date (Figure 7). Our sighting rate was 1.68 whales/hour on 28 April, peaked at 10.6 whales/hour on 2 May and dropped to 0.33 and 0.67 whales/hour on 5 and 6 May, respectively. Sighting rate on 10 May was 4.0 whales/hour. Thus, one pulse occurred between 28 April and 6 May, with an indication of a second pulse on 10 May. Similar migrational patterns were seen in previous years (Ljungblad et al, (a)1982, 1983), and are discussed in Braham et al, (1980).

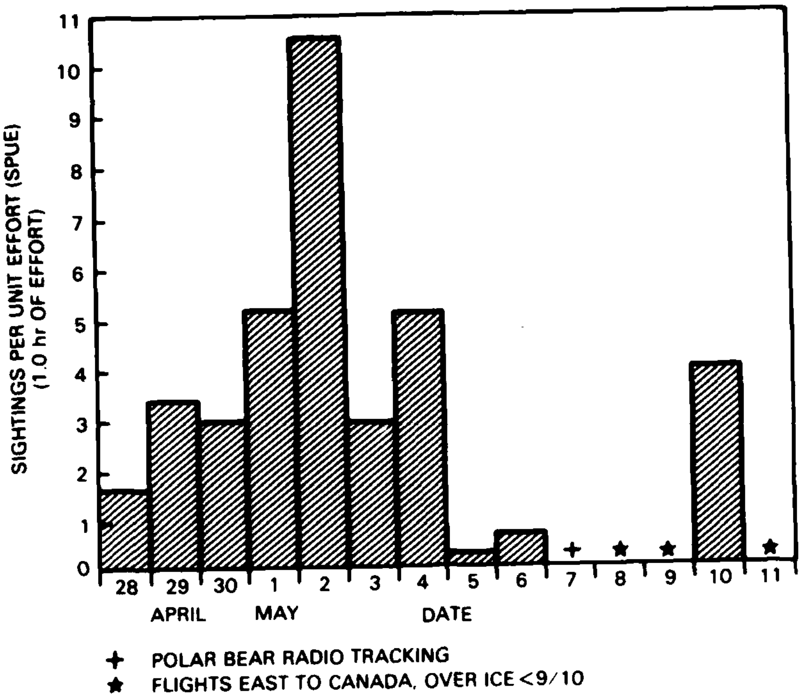


Figure 7. Bowhead sighting per unit effort (SPUE), by date spring 1983.

The timing of the spring migration was very similar to that seen in 1981 and 1982 (Ljungblad et al, (a)1982, 1983). The major pulse observed on 2 May correlates roughly with a peak SPUE noted in early May of the two previous years. The second peak on 10 May may indicate another pulse was moving past Point Barrow. This timing, with approximate 8 to 10 day delay between pulses is very similar to that noted in 1982 (Ljungblad et al, 1983). A calculation of SPUE by date for 1979 through 1983 spring data is presented in the conclusion section of this report.

The width of the migration route from Point Barrow to Oliktok (approx 149°W) based on the observed distribution was about 40 km. Too few sightings were made east of 149°W this season to project a reliable migration corridor width.

Bowheads that were seen east of 151°W were found in narrow discontinuous cracks that ran generally north and south. This indicates that whales migrate east through heavy ice areas by swimming from crack to crack in the absence of an east

to west lead system. How or if whales can detect distant cracks is unknown. Braham et al, (1984) report that bowheads look for open holes in heavy ice, and may form hummocks when they "push up on the ice to breathe", but if they cannot find or make openings they return to their original opening. These authors also note a personal communication from Eskimo whalers that bowhead exhalations have been heard under the ice when no apparent open water was available. The distribution and detection of whales migrating under such conditions is very difficult to determine or predict.

Behavior and Sound Production

Bowhead behavior, average group size and response to aircraft were summarized by sea (Table 6). Behaviors seen during spring, 1983 were typical of those seen in previous years, with the exception of more mating observed in the Beaufort Sea than in the past. The most common behavior was active swimming at an average overall estimated speed of 3.5 km/h. Whales that were not swimming were often involved in social behavior including possible mating, tail-slapping, and breaching. One whale that appeared to be alone (about 35 km from nearest sighting) was seen breaching four times on 28 April. All other display and mating behavior occurred in aggregations of 3 to 15 whales. The frequency of observed behaviors in each of the three seas was not significantly different ($\chi^2 = 4.95$, df = 16, $p \leq 0.20$).

Thirteen pairs of bowheads appeared to be mating (Tables 2 and 6). One pair was seen in the nearshore lead 30 km southwest of Cape Lisburne; all others were observed in the Beaufort Sea northeast of Point Barrow. Mating animals were most often accompanied by a third whale generally positioned near, if not in contact with, the pair and one to five other whales were often within roughly 200 m. Mating animals were often positioned along the edge of large cracks or leads rather than in the center of them. In the larger aggregations of 12 to 15 whales seen on 1 May and 2 May, whales near the mated couples were seen breaching and tail slapping and occasionally swimming toward the coupled whales. Although large aggregations (3 to 4 whale groups within 5 km) of bowheads were seen in the Beaufort Sea, average group size was greatest in the Chukchi Sea (Table 6). Overall average group size was 3.57, with a range of 2.0 to 6.0. Sample size for groups seen in the Bering and Chukchi Seas were too small for statistical comparisons.

Table 6. Summary of bowhead behavior, average group size, and response to aircraft, spring 1983. No. (%) = Number (percent).

Behavior*	Bering Sea No.(%)	Chukchi Sea No.(%)	Beaufort Sea No.(%)	TOTAL No.(%)
SWIM	3(100)	19(90)	143(72)	165(74)
DIVE	0(0)	0(0)	18(9)	18(8)
MATE	0(0)	2(10)	24(12)	26(11)
FLIPPER-SLAP	0(0)	0(0)	6(3)	6(3)
TAIL-SLAP	0(0)	0(0)	4(2)	4(2)
BREACH	0(0)	0(0)	4(2)	4(2)
TOTAL	3(100)	21(100)	199(100)	223(100)
Response to* Aircraft				
NO	2(67)	18(86)	112(56)	132(59)
YES	1(33)	3(14)	87(44)	91(41)
Average Group Size	$\bar{x} \pm sd$ (n)	$\bar{x} \pm sd$ (n)	$\bar{x} \pm sd$ (n)	$\bar{x} \pm sd$ (n)
	2.0 (1)	6.0 ± 4.24 (2)	3.5 ± 2.19 (48)	3.57 ± 2.27 (51)

*see p. 9 - 10
(n) = number of groups of two or more whales

Sonobuoys were dropped and sounds recorded near bowheads six times in the Beaufort Sea (Table 7). Calls were recorded most often from whales in groups that appeared to be involved in social behavior. All sounds were played back at the recorded speed and aurally (i.e., subject to listener's hearing) placed into simple or complex moan-sound categories based on past analyses of bowhead sounds (Ljungblad et al, (b)1982) (Table 8). Simple moans are tonal, frequency modulated (FM) sounds often with harmonic structure and usually in the 20 Hz to 2 kHz frequency band. They were classified to five categories based upon temporal frequency modulation as follows:

FM_1: up = ascending frequency modulation

FM_2: down = descending frequency modulation

FM_3: constant = no discernable frequency modulation

FM_4: inflect = combined ascending and descending frequency modulation

FM_5: high = short calls starting above 800 Hz.

Complex moans are amplitude modulated (AM) sounds. Amplitude modulation may be rapid resulting in well-defined components (Watkins, 1967) or slow resulting in non-uniform and varied component structure. Two categories of complex moans aurally recognized on the basis of frequency content are:

AM_1: growl = low frequency calls with energy primarily below 1 kHz

AM_2: trumpet = high frequency calls with energy primarily between 500 Hz and 4 kHz

Notably, growls can (and do) grade into trumpets with a shift in frequency.

Table 7. Location and recorded subject of sonobuoy drops, spring 1983.

Flt	Date	Location		Subject Species	Incidental Recording
6	30 Apr	71°34.5'N	154°40.8'W	Bowhead, Bearded Seal	Ambient
7	1 May	71°34.8'N	155°52.0'W	Bowhead, Bearded Seal	Ambient and Ice Noise
8	2 May	71°35.0'N	153°41.0'W	Bowhead, Belukha, Bearded Seal	Ambient
8	2 May	71°32.0'N	153°18.0'W	Bowhead, Belukha	Ambient
10	4 May	71°26.6'N	151°39.6'W	Bowhead, Belukha Bearded Seal	Ambient
15	10 May	71°31.5'N	155°57.1'W	Bowhead, Belukha, Bearded Seal	

Table 8. Results of initial aural analysis of bowhead calls recorded in spring 1983. No.(%) = Number (percent).

						Simple				Complex					
Date	Sample Duration (min.)	Number Whales	Call Rate	General Behavior	Behavior Index	Up No.(%)	Down No.(%)	Const. No.(%)	Inflect. No.(%)	High No.(%)	Growl No.(%)	Trumpet No.(%)	N	Noise	Comment
30 Apr	9	11	0.18	1 mating pair 2 whales swim toward pair	2.1	1(10)	1(10)		2(20)		4(40)	2(20)	10	Aircraft	Bearded seal; whale sounds are weak.
1 May	12	10	0.18	4 mating pair breach, tail slap, swimming	2.9	3(14)	6(29)		3(14)		8(38)	1(5)	21	Aircraft H_2O	Bearded seal; lots of water/ice noise.
2 May	50	32	0.18	3 mating pair paired swimming-swim toward pair	2.0	143(51)	15(5)		9(3)	2(1)	109(39)	4(1)	282	Aircraft	Bearded seal and belukha repetitive moans = 'ups' purr-like moans = 'growls'
4 May	22	4	0.39	1 mating pair swimming	3.0	9(26)	7(21)		1(3)		17(50)		34		Belukha sounds sometimes "masking" bowhead sounds. Bowheads in 7/10 to 9/10 ice.
10 May	39	10	0.11	1 mating pair swimming	1.0	2(5)	9(24)	1(3)	5(13)		21(55)		38	Aircraft	Beluka "masking" sounds of bowhead (barking type). Bearded seal
TOTAL	124			mating, swimming displaying		158(41)	38(10)	1(0.5)	20(5)	2(0.5)	159(41)	7(2)	385	Aircraft H_2O	Bearded seal and Belukha sounds.

Occasionally simple or complex moans exhibited both FM and AM components. Aurally these calls sounded "complex" and were so categorized for the purpose of this initial analysis. The sound categories presented here are comparable to those reported by Würsig et al, (1982) for bowhead sounds recorded in the eastern Beaufort Sea.

Call rate was derived as relative index of sound production by dividing the number of calls by the number of whales observed within 15 km of the sonobuoy drop site (Cummings and Holliday, 1983) for a sample unit (minute) of time. We assume by this method that all whales within 15 km of the sonobuoy drop site have equal probability of producing the sounds recorded. If individual call rates vary with extant behavioral states, as is the case in other species where animal signals have been studied (Dawkins and Krebs, 1978), this assumption will probably not be valid in most recording circumstances. At present, however, there is no way to determine which, or how many, whales of a group are producing sounds in a given sampling period.

Of a sound sample containing 385 discrete calls, 57 percent were simple and 43 percent were complex moans. Up calls (FM_1) were more common than any other type of simple moan. Growls (AM_1) were recorded as often as the up calls and far outnumbered trumpets (AM_2) in this sample. The biological significance of these sounds is difficult to interpret. An effort to derive a behavioral index relative to general activity states was made by ranking behavior as follows:

0 = resting
1 = swimming and diving
2 = milling
3 = feeding
4 = nurturing
5 = mating
6 = displaying

The assigned rank number was then multiplied by the number of whales exhibiting that behavior, and the sum divided by the number of whales seen. This method reflects only a crude index of observed surface activity at best. A multiple linear regression analysis comparing call rates and ratios to the number of whales and their calculated behavioral index found no significant correlations.

Efforts to correlate sound production with behavior are confounded by: (a) the aforementioned uncertainty as to which whales in a group were producing sounds, and/or (b) observers being unable to routinely categorize behavior of whales at the surface and unable to observe behavior of whales below the surface. Behavioral observations were further constrained by time limitations and fuel budgeting. When flying line transect surveys, remaining in an area to observe whale behavior during sound recording sessions usually resulted in transect surveys being curtailed.

The two most exciting results of the preliminary sound analysis are the repetitive moans and the aurally distinct purr-like moan recorded on 2 May. While moan sequences have been reported for bowheads previously (Ljungblad et al, (b) 1982), the repetitive moans recorded in spring 1983 were unlike those previously analyzed. These sounds are of the simple moan (FM) type and are inflected upward with a duration of about 1 s. Five to eight ($\bar{x}$ = 5.8 $\pm$ 1.0 s.d.) such calls were given per sequence with an interruption of about 1.5 s before the next sequence is initiated. Presently we have no way of determining if one or many whales are responsible for such a moan sequence.

The purr-like moan was recorded in the presence of a comparatively large, socially active group with at least one large mottled whale present. Similar purr-like moans were recorded one other time (29 May 1980), also in the presence of a large mottled whale with at least three other bowheads nearby. Notably, no purr-like moans were recorded on 10 May when 9 mottled whales were seen. Würsig et al (1982) reported on a purr-like moan which had many harmonics recorded near bowheads in the eastern Beaufort Sea. We do not yet know if this is the same type of sound.

Molting or Mottled Whales (Morphological variants)

Unusually colored whales, labelled "morphological variants" were seen with normally pigmented bowheads this year as in previous years (Ljungblad et al 1980, (a)1982. Fifteen (7 percent, n=223) such whales were seen, including one cow-juvenile pair, distributed between Point Barrow and Cape Halkett.

A commonly held hypothesis is that these whales are molting or sloughing their skin. A photographic series taken in the eastern Beaufort Sea in 1982 (Davis et al, 1983) shows bowheads sloughing large areas of skin and having a changing

mottled appearance as the molting process proceeds. The whales we saw may, in fact, be such molting animals. Additional morphologic differences were noted, however, and are listed below:

- Mottled whales were always very large individuals with subjective size estimates ranging from 17m to 21m.
- The head of the mottled whales appeared flatter and broader, lacking the distinctive arch of the bowhead.
- The girth of the mottled whales, just aft of the pectoral flippers appeared at least one fourth greater than that of typical bowheads.
- The mottled whales are light to dark brown overall often with a chalky white coloration on the top of the head extending back past the blowhole. This whitish coloration does not seem to be that of callosities, as the head's surface appears smooth, lacking prominent bumps or "bonnets." Mottled whales lack the distinctive white chin patch and tail chevron markings of many normal bowheads.

The mottled whales we observed were very responsive to aircraft disturbance. Most dove on approach of the aircraft and if they were resighted were often seen just subsurface. As a result, most of the mottled whale photos show submerged whales on which distinguishing features are difficult to identify.

Displays of social behavior involving mottled whales were not seen, nor were pronounced individual displays such as spy-hops, or breaches. When sighted, the mottled whales were always swimming at an average of 2 to 6 km/h, paced by the whales they accompanied. As previously mentioned, an aurally distinct purr-like moan was recorded on 2 May in the presence of a mottled whale and 14 normal bowheads.

OTHER SPECIES

Belukha whales (Delphinapterus leucas)

In spring 1983, 1397 belukha whales were seen ahead of, accompanying (as close as 20 m), and well behind the main group of migrating bowheads we observed (Figure 8). Over 400 were seen north of St. Lawrence Island on 24 April. On that date most (n=320) of the whales seen remained motionless at the surface. On all other sightings they were swimming and appeared to be actively migrating.

Belukhas seen northeast of Point Barrow were generally north of bowhead sightings. These whales most often swam in groups of 5 to 20 comprising aggregations numbering into the hundreds. After rounding Point Barrow they

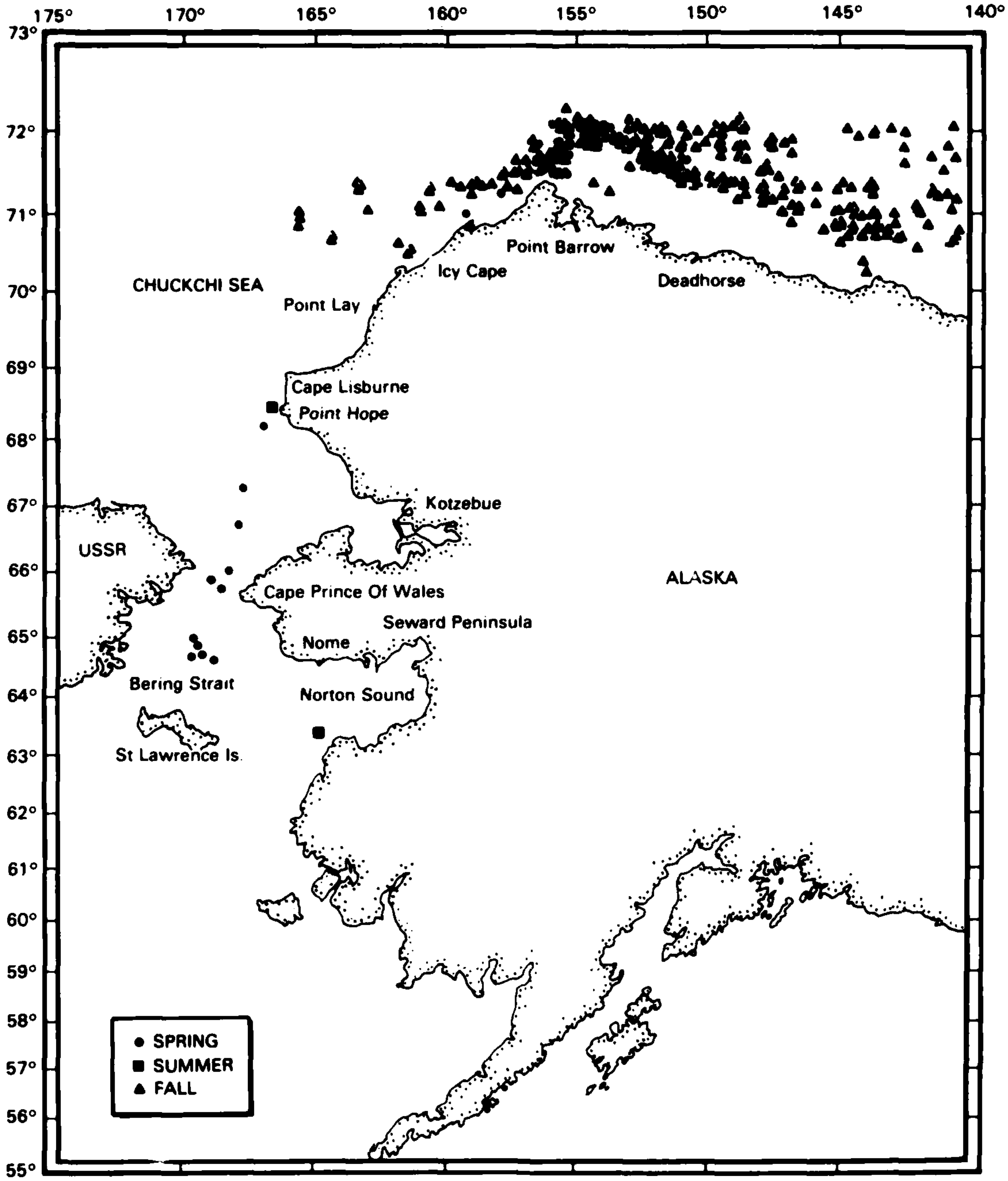


Figure 8. Distribution of 385 sightings of 3761 belukha whales in all seasons, 1983.

apparently move to deeper water north of the bowhead migration route while actively migrating in an easterly direction. This apparent segregation in the migration of the two species has been noted in previous years (Ljungblad et al, (a) 1982).

On 10 May belukhas observed near Point Barrow were seen spy-hopping or breaching. As groups of 8 to 15 were seen swimming north and east in the open leads northeast of Point Barrow, individual whales would pop out of the water to half their body length then continue swimming with the group. This was the only flight on which such behavior was noted.

Belukha sounds were recorded on most of the spring tapes (see Table 8). On recordings made on 4 May and 10 May their calls dominate portions of the tape as the whales passed by the hydrophone.

Pinnipeds

Bearded seals (Erignathus barbatus), ringed seals (Pusa hispida), walrus (Odobenus rosmarus) and one ribbon seal (Histriophoca fasciata) were seen in spring 1983. Most of the bearded seals (80 percent, n=54) and all of the walrus were seen in the Bering Sea north of St. Lawrence Island. Ringed seals were seen north of St. Lawrence Island, southwest and northeast of Point Barrow, and as far east as the U.S./Canadian border. Walrus and ringed seals usually responded to the aircraft by diving from ice into the water. Bearded seals usually did not respond, but remained "hauled out" on the ice. The lone ribbon seal was seen north of St. Lawrence Island on 21 April (Appendix A: Flight 1). The seal remained on the ice showing no apparent response to the aircraft. These seals are generally found in the northwest coastal region of the Bering Sea, north to St. Lawrence Island, the Sea of Okhotsk and Tartar Strait (Coffey, 1977). Twelve pinnipeds were not identified as they were too far away from the aircraft, or dove in response to the aircraft.

Polar Bear (Ursus maritimus)

Nine polar bears were seen in spring 1983. Four bears, consisting of two (probable) sow-juvenile pairs, were seen north of St. Lawrence Island on 24 April (Appendix A: Flight 2). Five bears were seen northwest of Wainwright on 25 April (Appendix A: Flight 3), including one (probable) sow-juvenile pair. Notably no bears were seen on the Beaufort Sea ice, nor were any seen with collars or distinguishing markings. All bears responded to the aircraft by running across the ice.

Summer (July) 1983

Survey Effort, Rationale and Sighting Summary

Twenty-five and one-half survey hours were flown in the summer with 82 percent (21 h) in the northern Bering Sea and 18 percent (4.5 h) in the southeastern Chukchi Sea (Table 9). Most survey time was devoted to line transect surveys in blocks A, C, and E (Figure 1; Appendix A: Flights 17 to 23). A coastal search survey was conducted in the eastern Chukchi Sea on 31 July (Appendix A: Flight 24). Surveys were designed to determine the distribution, relative abundance, and, to the extent possible, the gross behavior and movement of gray whales in the northern Bering and eastern Chukchi Seas in July.

Survey Conditions Summary

Surveys in the northern Bering Sea often had to be truncated or modified due to persistent low fog. On clear days, high sea states (Beaufort 03 to 06) often hampered surveys. Overall, average sea state ranged from Beaufort 01 to 04. Visibility averaged 5 to 10 km.

GRAY WHALE (Eschrichtius robustus)

Distribution and Relative Abundance

Four hundred thirty-five sightings of 1026 gray whales were made in summer (Figure 9). Extremely high concentrations of grays were seen in the western half of block C and block E on 20, 21, and 22 July (Appendix A: Flights 17, 18 and 19). Additional areas of concentration were near the southeastern coast of St. Lawrence Island; a portion of the Chirikov Basin northwest of King Island extending to the Bering Straits, and along the coastline extending roughly from Icy Cape to Point Barrow. This distribution is generally similar to that seen in previous years (Moore and Ljungblad, 1984). A comparison of observed gray whale distribution and density from 1980 through 1983 is provided in Appendix B.

Gray whales were seen from 5 m to 140 km from shore in water ranging from 4 m to 40 m deep. A few whales observed near Wainwright on the Chukchi coast appeared to be resting on the bottom.

The 21 grays encountered near the Chukchi coast between Icy Cape and Point Barrow on 31 July represent 2 percent of all grays seen. These whales probably moved north through the Bering Strait sometime between late May and early July as no net northward movement was evidenced by gray whales we saw in the Chirikov Basin area during July (see Figure 10).

Table 9. Survey effort and sighting summary*, summer 1983

Flt	Date	Survey Effort	Gray Whale	Belukha Whale	Killer Whale	Walrus	Comments
17	7/20	Block C	26/282	0	1/9	1/1	Low fog in southern legs
18	7/21	Block E	163/319	0	0	0	Concentrations of grays feeding; clear calm
19	7/22	Block C	186/310	0	1/1	0	Concentrations of grays feeding; clear calm
20	7/23	Block A	(1D)	1/4	0	(38D)	Seismic vessel M.V. Bollinger in central Norton Sound
21	7/28	Block C Abort	0	0	0	0	Very low ground fog covering all survey areas
22	7/29	Block C Abort	28/49	0	0	0	Fog over entire basin
23	7/30	Search St. Lawrence Is.	25/45	0	0	0	Low fog covering most of survey areas
24	7/31	Nome to Pt. Barrow	7/21 (8D)	1/1	0	(84D)	7 gray stranded, 1 floater 1 Unidentified cetacean
		TOTAL	435/1026 (9D)	2/5	2/10	1/1 (122D)	

* In the species columns, the numbers represent numbers of sightings/number of individuals. D = dead.

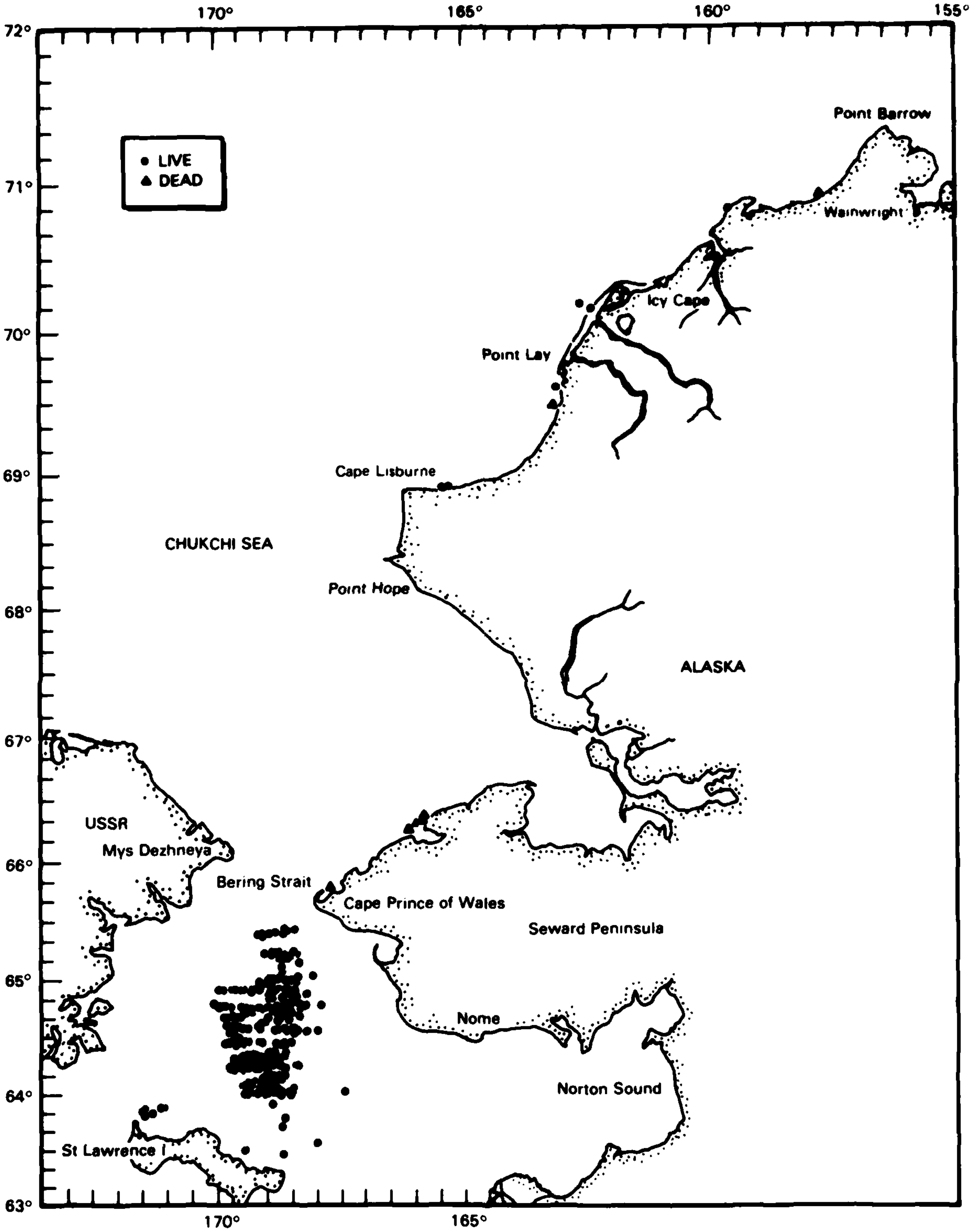


Figure 9. Distribution of 435 sightings of 1026 gray whales, summer 1983.

The distribution of gray whales on their northern range appears to be highly dependent on prey availability (Braham, 1984; Nerini, 1984). Gray whales move into the Chirikov Basin sometime in May to feed. Some may swim from the coastal waters of the Alaskan Peninsula where they have been observed apparently feeding in significant numbers in early spring (Gill and Hall, 1983). Fewer whales were seen along the Alaskan Peninsula in mid-summer (when many were seen in the Chirikov Basin); there is a resurgence in number from late summer until late November when they depart for their wintering grounds. Between 1981 and 1983, 2 percent to 35 percent of all gray whales seen in July were found along the Chukchi coast, and up to 30 percent of these whales apparently were feeding. The year of highest incidence of observed feeding corresponded to the year of highest (see Table 25) density. Thus, as far as whale movements are directed by food requirements, annual differences in prey availability along the coastal Chukchi shelf would account for the apparent large variability in the number of grays seen there each year.

Only one gray whale calf was seen this year in the Chirikov Basin. This contrasts sharply with 1982 data when 19 calves were incorporated in a total count of 320 grays (5.94 percent). One calf in a count of 1026 (0.1 percent) whales seems disproportionately low. In 1982 gray whales with calves appeared to be a geographically separate group (Ljungblad et al, 1983). Eighteen calves were among the 111 gray whales distributed between Cape Lisburne and Wainwright, while only one calf was seen in a total of 209 whales sighted between St. Lawrence Island and 50 km southwest of Point Hope. There was roughly a 150 km separation between the first sighting of the group of 111 gray whales seen on 31 July and the most northerly gray whale sighting prior to that date in 1982. These data may indicate that some segregation of cow-calf gray whale groups occurs on the northern range, and that such segregation may be an extension of a segregation found in migrating grays (Sumich, 1976, pp. 233-234). If, in fact, such segregation of cow-calf pairs does occur in gray whales, the low calf count this year may be the simple result of not finding such a group.

Nine gray whale carcasses were seen either floating or beached on shore in the northern Bering and Chukchi Seas (Figure 9 and Table 10). The cause of mortality could not be ascertained, though several carcasses seemed to have lacerations about the flippers. Most beached carcasses were in an advanced stage of decomposition. None were at locations of carcasses from previous years (Ljungblad et al, (a) 1982 and 1983).

Table 10. Location of gray whale carcasses, summer 1983

Flt	Date	Location	Comment
20	23 July	64°45.9' 160°45.0'	Beached, estimated, 8m
24	31 July	65°48.5' 167°37.4'	Floating belly up, est. 12m
		66°16.2' 166°03.2'	Beached, 12 to 14m
		66°19.0' 165°53.0'	Beached, 12 to 14m
		66°20.4' 165°47.3'	Beached, 12 to 14m
		66°21.6' 165°43.6'	Beached, 12 to 14m
		67°58.3' 165°55.9'	Beached, 12 to 14m
		69°28.1' 163°06.3'	Beached, 12 to 14m
		70°53.2' 157°43.2'	Beached, 12 to 14m

Behavior and Sound Production

The headings of gray whales in July were generally southwest (Figure 10). There was clustering about the mean heading of 155°M (180°T, $z=23.35$, $n=150$, $p\leq.001$) during a transect survey of block C east of St. Lawrence Island on 22 July (Appendix A: Flight 19). Headings were nonrandom and concentrated in the two southeast octants ($X^2=47.03$, $df=7$, $p\leq.001$). During a search survey near St. Lawrence Island on 30 July (Appendix A: Flight 23) there was clustering about the mean heading of 245°M (270°T, $z=7.07$, $n=14$, $p\leq.001$). Headings were nonrandom and concentrated in the western octants ($X^2=21.43$, $df=7$, $p\leq.001$). These headings would be expected of whales swimming along the island's coastline. Gray whales observed on flights in this area on 20, 21, and 29 July held random headings, but showed some clustering about the mean headings: 182°M, $z=4.14$, $n=13$, $p\leq.025$; 178°M, $z=3.10$, $n=82$, $p\leq.05$; and 210°m, $z=3.19$, $n=15$, $p\leq.05$, respectively. These mean headings were between the extreme headings recorded on 22 and 23 July. This is not surprising as all these flights surveyed the same general area.

Gray whales sighted with mud plumes were assumed to be feeding. Mud plumes are large billows of sediment that in calm waters (Beaufort 00 to 02) may retain their identifiable shape and subsurface discoloration for 5-10 minutes and are excellent sighting cues. Mud plumes also attract feeding birds (Harrison, 1979)

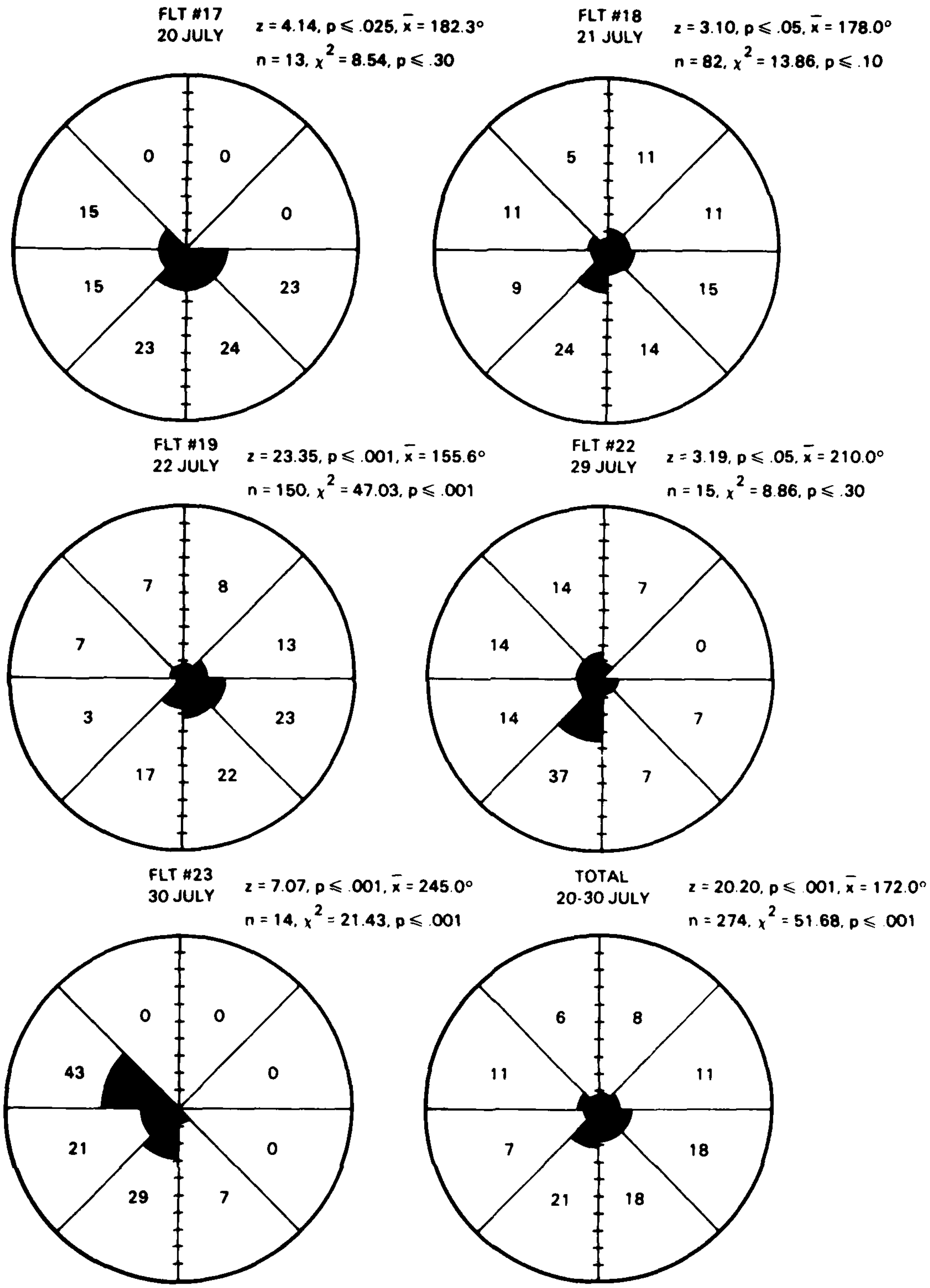


Figure 10. Direction of gray whales in the northern Bering Sea, summer 1983. Numbers within the pie diagrams are percentages.

that aid sightability. Gray whales often were sighted soon after we started seeing plumes. Thus, plume-only sightings were recorded again this year, and though they are not included in our distributional or density data, we feel they are good indicators that gray whales were present. Most of the gray whales seen in the Chirikov Basin were feeding. Whales that were not feeding were swimming slowly (1 to 3 km/h) in all directions, or resting. Several underwater blows were seen as whales rose in the water column to breathe.

Gray whale rate of response to aircraft was generally low as the aircraft usually remained on transect course with a minimum amount of circling. The grays that were observed for any period of time were primarily feeding. On 22 July a group of 10 to 12 feeding grays was observed from an altitude of 1500 feet for approximately 1.3 hours. Smoke flares and sonobuoys were dropped during these observations. No avoidance responses or behavioral effects were noted. Whales spread across the observation area northwest of King Island continued to dive and surface with large mud plumes. Many approached or passed near the smoke flares (i.e., estimated at less than 20 m) during these observations showing no avoidance responses. Whales did respond to the aircraft on the 31 July (Appendix A: Flight 24) coastal survey from Nome to Point Barrow. These responses may have been due to the low altitudes (153 m or less) that the aircraft maintained during the coastal survey due to low visibility ceilings.

Sonobuoys were dropped three times in the Chirikov Basin (Table 11). Sounds were recorded on 22 July near a group of 10-12 feeding gray whales northwest of King Island. The sounds recorded were similar to those previously reported for gray whales on their northern range (Moore and Ljungblad, 1984). Most sounds were grunt or belch-like calls termed N_4-type calls. This deviates from past samples when short duration metallic-sounding pulses (N_1-type) were the most prevalent type of sound recorded near grays. A couple of such N_1-type sound series were recorded. There were several sounds recorded that may be underwater blow-sounds. Observers from the air found it impossible to correlate underwater blows seen with the sounds recorded. Dahlheim et al, (1984) reports such sounds recorded near gray whales in their breeding lagoons. This is the first (possible) report of the underwater blow sound (N_6-type) on the northern range.

The seismic vessel MV DON BOLLINGER was monitored for seismic sounds on 23 July in the central Norton Sound. The vessel was inactive and no sounds were recorded.

Table 11. Location and recorded subject of sonobuoy drops, summer 1983.

Flt	Date	Location	Subject	Incidental Recording
17	20 July	63°23.7' 168°22.6'	Killer whales	Ambient
19	22 July	65°05.0' 168°44.0'	Gray whales	Ambient
20	23 July	63°46.5' 165°05.0'	Vessel	Ambient

OTHER SPECIES

Killer Whales (Orcinus orca)

Nine killer whales were observed for approximately ten minutes on 20 July in the Chirikov Basin about 22 km northeast of St. Lawrence Island. A sonobuoy was dropped near these whales, but no sounds were recorded. Low fog precluded continued observation of the killer whales.

Belukha whales

Four belukhas were seen on 23 July apparently feeding in the Yukon River Delta area. One additional belukha was seen on the coastal survey on 31 July. The distribution of belukhas sighted in summer is plotted with spring and fall sightings (Figure 8).

The population of belukhas that occurs within the Bering Sea appears to be composed of both resident and migratory groups. It is not presently known what portion of the Bering Sea population of belukha whales migrates north and east into the Beaufort Sea with the bowheads in spring, and what portion remains in the Chukchi and northern Bering Seas. Though we saw only three belukhas in the Bering Sea in July 1982, over 130 belukhas were seen feeding near the Yukon River Delta in July 1981. The Alaska Department of Fish and Game reports that a resident stock of 1,000-1,500 belukhas occurs in the Bristol Bay-Kuskokwim Bay area year around (Klinkhart, 1966). Unknown numbers of belukhas apparently overwinter in the Bering Sea north of Bristol Bay (Fay, 1974). Most of these animals probably migrate north with the bowheads as the ice recedes in the spring while a portion of this subgroup remains in the Yukon River Delta region or Kotzebue Sound area.

Unidentified cetaceans

One cetacean sighted swimming below the surface near Icy Cape was estimated to be 2 m in length. It was mostly black with white markings. This animal was swimming very rapidly through the water and may have been a Dall's porpoise (Phocoenoides dalli).

Pinnipeds

One live walrus was seen in the Chirikov Basin on 20 July. Thirty-eight floating walrus carcasses were seen in Norton Sound on 23 July, and 84 carcasses (many along the beach) were noted on the Chukchi coastal survey on 31 July.

Fall (August - October) 1983

Survey Effort, Rationale and Sighting Summary

A total of 318½ survey hours was flown in the fall with 84 percent (267.5 h) of this effort in the Beaufort Sea and 16 percent (51 h) in the Chukchi Sea (Table 12). Surveys in the Beaufort Sea were scheduled so that all blocks were flown, or at least attempted, before any block was repeated. Also, surveys of offshore blocks were preceded and followed by surveys of nearshore blocks to balance the effort between the two areas. Restrictive weather or exceptionally heavy aircraft traffic precluded surveying some blocks on their prescribed day, altering the above plan to some degree, but a representative sampling was accomplished at least every two weeks.

Usually two adjoining blocks were flown per flight for efficiency. A refueling site was available at Point Barrow but not at Barter Island (as in previous years). Trips to and from blocks were devoted to search surveys along the coast, selected isobaths, or the ice edge.

Since the transit times to the various Chukchi Sea blocks from Point Barrow (or Kotzebue as an alternate) were relatively long, not all blocks were surveyed within the allocated flight hours. First priority was given to coastal blocks. The shifting ice edge or 40 m isobath were assigned second priority with the blocks furthest offshore given the lowest priority.

The survey effort and area coverage in the Beaufort Sea was similar to 1982 (Ljungblad et al, 1983) but greater than that flown in 1979 through 1981 (Ljungblad et al, 1980, (a) 1982; Ljungblad, 1981). The effort in the Chukchi Sea was somewhat greater than 1982 and far greater than 1979 to 1981. The distribution of bowheads through the Beaufort and Chukchi Sea in 1983 was similar to past years. Surveys were not flown on nine days in August, six in September and three in October due to bad weather or aircraft maintenance requirements.

Survey Conditions Summary

In July, before aerial surveys continued in the Alaskan Beaufort Sea, the ice was quite heavy and congested (R. Scheidt, personal communication*). In mid-July there was some open water in Canada near river mouths and by late July the open water had spread west to about the U.S.-Canada border with some open water in Smith and Harrison bays.

*R. Scheidt, NESS, NWS, NOAA, Dept. of Commerce, Anchorage, AK 99513

Table 12. Survey effort and sighting summary,* fall 1983.

Flt	Date	Survey Effort	Bowhead Whale	Belukha Whale	Gray Whale	Bearded Seal	Ringed Seal	Unknown Pinniped	Walrus	Polar Bear	Comment
25	7/31	Search: Pt. Barrow - Deadhorse	0	0	0	0	0	1/1	0	0	
26	8/2	Transect: 6,7 Search: 6	7/8	0	0	0	0	0	0	0	3 bowheads breaching
27	8/3	Transect: 7	0	3/4	0	0	0	0	0	0	
28	8/4	Transect: 3	0	0	0	0	0	0	0	0	
29	8/5	Transect: 8 Search: 7	6/21	2/4	0	0	0	0	0	0	Bowheads along ice edge
30	8/8	Transect: 6,7 Search: 5	0	0	0	0	0	4/4	0	0	1 vessel
31	8/9	Transect: 5,9	7/15	1/1	0	3/5	0	16/22	0	0	Bowheads feeding
32	8/10	Transect: 5,7	5/5	5/12	0	1/1	0	6/11	0	0	3 vessels, probable calf
33	8/15	Transect: 3 Abort	0	0	0	0	0	0	0	0	Very poor visibility
34	8/17	Transect: 12 Search: 3	0	1/50	1/13	0	0	14/16	1/35	0	1 vessel, grays feeding
35	8/18	Transect: 8,9	0	11/44	0	0	0	5/5	0	1/2	
36	8/19	Transect: 3	0	0	0	0	0	3/3	0	0	
37	8/20	Transect: 7	3/5	1/1	0	0	0	5/5	0	0	1 vessel
38	8/21	Transect: 5	0	0	0	4/4	0	5/5	0	0	4 vessels
39	8/23	Transect: 7	1/1	0	0	0	0	1/1	0	0	2 vessels
40	8/24	Transect: 4,6	0	4/8	0	2/2	0	5/5	0	0	2 vessels, belukha nursing
41	8/25	Transect: 10	0	3/3	0	0	0	7/15	0	0	
42	8/26	Transect: 2,3	1/1	3/8	0	3/3	0	7/8	0	0	
43	8/27	Transect: 3,12	0	6/26	1/1	3/3	0	14/15	4/20	1/1	
44	8/28	Transect: 10,11	0	2/9	0	2/2	0	11/13	0	0	Belukha cow/calf pairs
45	8/29	Transect: 1,11	0	0	0	5/6	1/3	23/37	1/7	1/1	1 ribbon seal
46	8/30	Transect: 5,7	1/1	1/2	0	0	0	6/6	0	0	
47	8/31	Transect: 7,8	1/2	0	0	1/1	0	6/7	0	0	2 vessels
48	9/2	Transect: 2,10	0	7/20	0	0	0	5/5	0	1/2	
49	9/3	Transect: 4,6	7/9	6/15	0	0	0	5/7	0	0	2 bowhead calves
50	9/5	Transect: 3,12	0	3/41	0	0	0	9/12	4/13	0	2 vessels
51	9/6	Transect: 7,8	5/5	7/65	0	0	0	4/4	1/1	0	Breaching bowhead
52	9/7	Transect: 5,6	0	1/1	0	0	0	8/25	0	0	1 vessel - CAN ice breaker
53	9/8	Transect: 9,10	2/2	13/48	0	0	0	2/2	0	1/1	1 vessel near Deadhorse
54	9/9	Transect: 11,12	0	3/7	0	2/2	0	12/20	1/1	2/6	5 polar bears at kill site = 71 16.5, 153 38.9
55	9/10	Search 9 Transect: 7,6	1/2	6/9	0	0	0	3/3	0	0	Bowhead cow-calf - calf swims At surface with open mouth
56	9/13	Transect: 2, 10	2/2	17/130	0	5/7	0	35/90	0	0	Transect 25 nautical miles east of E.O. Vetter

Table 12. (cont.)

Flt	Date	Survey Effort	Bowhead Whale	Beluhka Whale	Gray Whale	Bearded Seal	Ringed Seal	Unknown Pinniped	Walrus	Polar Bear	Comment
57	9/14	Transect: 3,11	0	3/24	0	0	0	1/1	0	0	Fog with some open patches
58	9/15	Abort Transect: 3,11	2/4	17/126	0	5/7	0	20/29	10/141	3/3	
59	9/16	Search 1,2 Transect: 1,2	6/7	0	0	1/1	0	15/19	0	1/1	One bowhead breached 5 times
60	9/18	Transect: 12, 11	11/13	24/204	0	5/6	0	2/2	4/140	2/2	One bowhead 17' tail lob 10' breach and pectoral slap
61	9/19	Transect: 6 Abort	0	0	0	0	0	1/1	0	0	Low fog - terminated after 90 miles out 300'
62	9/21	Transect: 5,6, 10,2	4/6	7/44	0	0	0	9/10	0	1/1	
63	9/22	Transect: 1,2,10	1/1	10/40	0	0	0	5/8	0	2/2	
64	9/23	Transect: 3,11	5/5	13/68	0	0	0	2/2	0	1/1	Enroute to Barrow
65	9/24	Transect: 12,13, 17	6/11	9/271	0	3/3	0	3/4	12/405	4/5	1/1 possible bowhead 1 bowhead 10' tail lob
66	9/25	Transect: 13	0	0	0	1/1	0	0	3/56	0	Abort flight due to icing
67	9/26	Abort Transect: 12	4/4	11/114	0	1/1	0	0	1/20	3/20	1 bowhead large white tail Chevron - 20 polar bears!
68	9/27	Transect: 12,13	1/2	1/40	1/2	0	0	5/5	6/129	1/3	Flight truncated due to icing
69	9/28	Transect: 3,11	0	31/184	0	4/5	0	12/18	0	0	
70	9/29	Transect: 6,5,4	3/5	8/124	0	0	0	3/3	0	0	Coastal low
71	9/30	Transect: 1,2	0	9/43	0	0	0	1/1	0	0	
72	10/1	Transect: 3	1/2	1/200	0	1/1	0	0	0	0	
73	10/2	Search 5 Transect: 5	4/6	1/5	0	1/1	0	1/1	0	0	1 bowhead tail slapper, 2 bowhead cow/calf
74	10/4	Transect: 11,12	4/7	8/53	0	0	1/1	2/6	0	1/1	2 bowhead with brown heads 1 mostly brownish
75	10/5	Search 5 Transect: 4, 6	0	2/9	0	0	1/1	4/5	0	0	
76	10/7	Transect: 1,2	0	6/27	0	2/3	0	2/2	0	2/2	
77	10/8	Transect: 3,11 Transit to Barrow	1/1	6/45	0	1/2	0	4/5	1/3	0	
78	10/10	Transect: 12,13	0	6/32	0	0	0	2/2	4/5(1D)	0	
79	10/11	Transect:14 Transit to Deadhorse	0	1/9	0	0	0	0	12/16	4/6	
80	10/12	Transect: 4,6,12	1/1	5/8	0	0	0	4/4	0	0	
81	10/13	Transect: 22 Refuel Kotzebue	0	0	6/10	2/2	0	6/9	23/1387(2D)	1/3	
82	10/14	Transect: 15 Search 73°N Line	2/3	4/6	0	0	0	1/1	0	4/4	
83	10/15	Transect: 17	4/4	7/19	0	0	0	1/1	4/105	0	
84	10/16	Transect: 12 Abort	0	2/6	0	0	0	0	0	0	
85	10/17	Transect: 18	4/6	10/90	0	1/2	0	1/1	8/10	5/12	
86	10/18	Transect: 12, 13,14	3/5	6/60	0	0	0	0	0	2/2	
87	10/19	Transect: 20,21 Transit to Nome	0	0	0	0	0	2/2	3/4(1D)	1/3	
		TOTAL	116/172	314/2359	9/26	59/71	3/5	331/489	103/2498(4D)	45/84	

*In the species columns the numbers represent number of sightings/number of individuals.

In early August the ice coverage in the Alaskan Beaufort Sea was heavy and quite homogenous. It consisted of broken, single-year floe ice with few large ponds or leads. Coverage exceeded 95 percent throughout the area except inside the barrier islands, in bays and inlets, along the coastline, and east of Barter Island. There was also about 1/10 multi-year ice mixed with the single-year ice north of Point Barrow in the northwest corner of block 12. There was strip of lighter ice coverage between the barrier islands and the predominant, heavier ice field north of the 30 m isobath. The width and ice density of this strip was highly dependent upon winds and currents which closed it to the islands occasionally, but more often opened it to as wide as 15 km from shore.

Newly formed grease ice was seen on 26 August and thereafter north of Deadhorse. It accounted for up to 5 percent of the total coverage especially after calm nights. Scattered floe ice was also seen inside the barrier islands on 30 August after a northerly wind. This wind also blew ice south against the mainland so that the coastal open water strip was displaced further offshore. It was centered on 70°N at the 141°W line on 31 August.

Overall ice conditions in the Beaufort Sea during most of September remained heavy and were very similar to those encountered in August (Figure 11). A narrow 3 to 10 km swath of open water extended from shore to a 3/10 to 9/10 ice field. Open water areas varied daily with current and wind direction and speed. Ice was pushed into shore at Barrow and south to Wainwright in the Chukchi Sea during the latter half of September. Coverage in these areas consisted of 8/10 to 9/10 single year floe ice.

A dramatic change in ice coverage began on 29 September when a strong (70 km/h) wind out of the northeast began moving ice offshore. Resultant ice conditions in the Beaufort and Chukchi Seas are shown in the 29 September satellite photo (Figure 12). By 1 October open water extended approximately 80 km from shore in the Beaufort Sea. There was no grease ice in Harrison or Camden Bays nor along the barrier islands. The wind shift also moved ice offshore at Barrow and in the Chukchi Sea south to Wainwright. Open water extended approximately 10 km offshore at Barrow, and about 80 km offshore at Wainwright on 4 October.

Though the major ice field remained 60 km to 80 km offshore during the first week of October, new grease ice was seen in Smith and Camden Bays on 4 October and 5 October, respectively. The extent of nearshore grease ice appeared

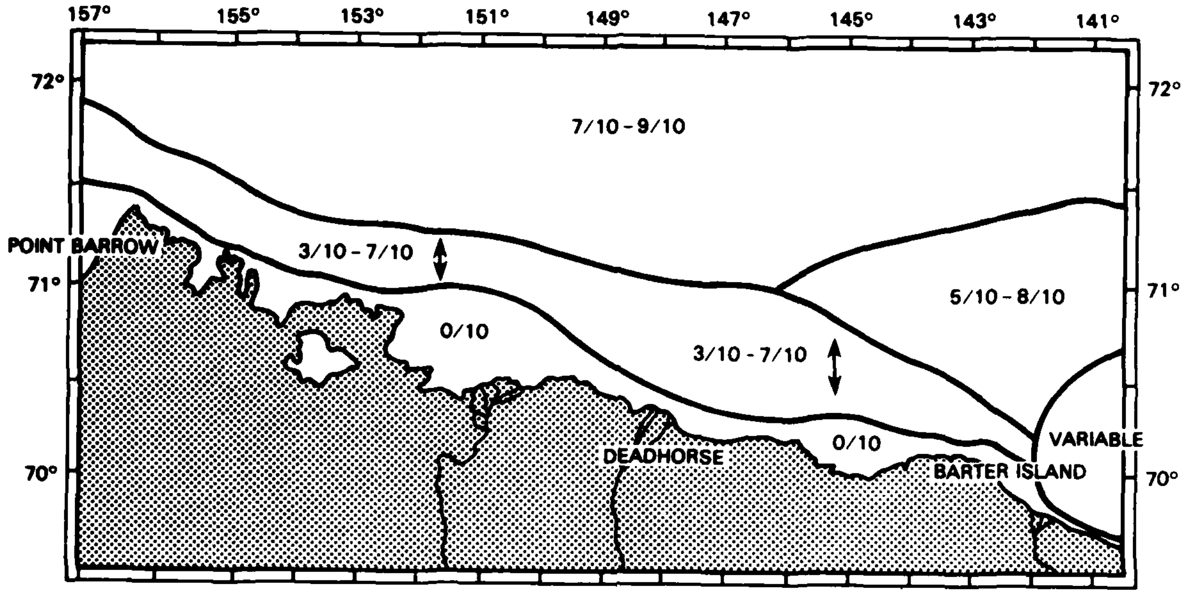


Figure 11. Schematic presentation of Beaufort Sea ice conditions in August and September 1983.

dependent on wind conditions which were quite variable during this period. By 8 October the water inside of the barrier islands was frozen solid and there was over 9/10 ice coverage inside the 20 m isobath including all bays and inlets. A strip of nearly open water persisted north of the 20 m isobath that was up to 60 km wide in places. There were some patches of new or grease ice and some pieces of old ice in this strip. North of this strip was mostly new pan or broken old floe ice with grease ice in the holes and cracks. Coverage was denser to the north such that it was over 9/10 with occasional multi-year pack ice pieces at 72°N. Bowheads could, however, migrate through this area as the new ice in the holes and cracks did not appear to be thicker than 0.2 m and was broken in pieces smaller than one meter across in some places.

There was less than 100 m of shorefast ice consisting of broken floe and new ice in the northeastern Chukchi Sea in early October. Actual freeze-up, the dramatic transition from mixed water and ice to solid ice, began on 9 October with a strong (up to 70 km/hr), cold (less than -9°C), northerly (000°-040°M) wind that blew through the end of the surveys . The open water of the Beaufort Sea was changed into ice by a combination of freezing and accumulation of ice blown from the north (Figure 13). Block 12 was almost solid on 16 October except for an area under the influence of Chukchi Sea currents.

Figure 12. Satellite photo showing Beaufort and Chukchi Sea ice conditions, 29 September 1983.

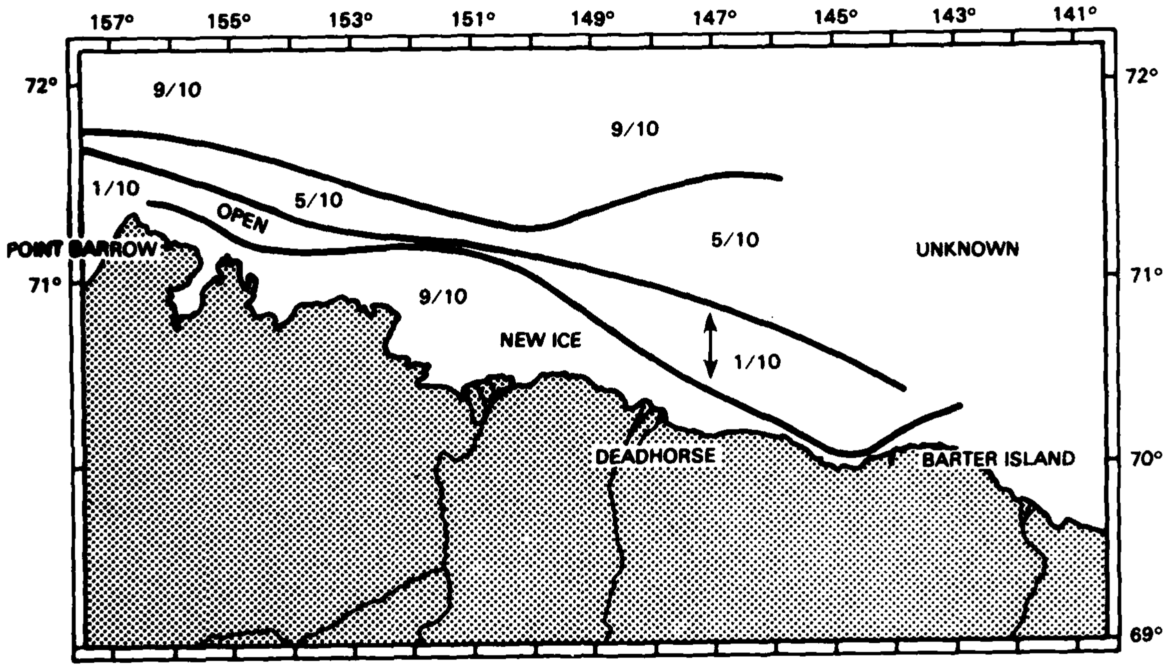
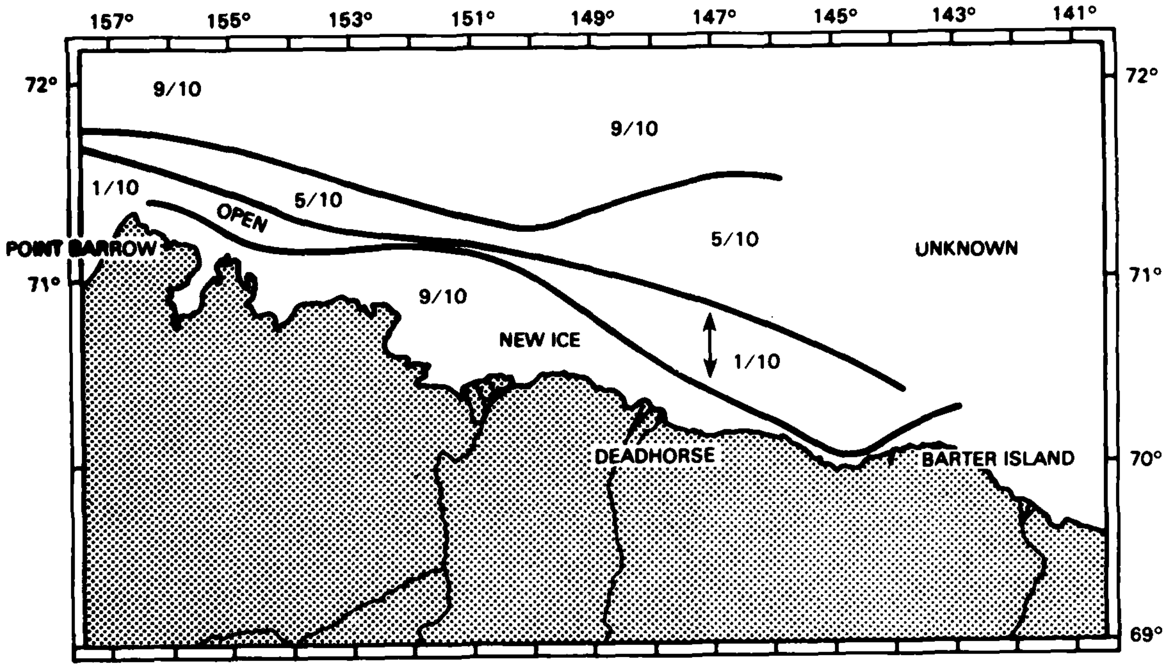


Figure 13. Schematic presentation of Beaufort Sea ice conditions, October 1983.

During freeze-up, the ice in the Chukchi Sea moved south and closer to shore by 10 to 15 km each day (Figure 14). On 14 October this advancing ice edge was noted north of a line from 72° 20'N, 157°W to 71° 40'N, 166°W. There was also a build-up of new ice from the shore out to about the 20 m isobath south of Point Barrow. This shorefast ice was 20 to 30 km wide offshore between Cape Lisburne and Icy Cape. New ice was noted against the shore in northern Norton Sound on 20 October in transit to Anchorage.

The sea state during most surveys ranged from Beaufort 01 to 03. A 00 sea state was often encountered in areas of heavy ice cover, as the ice acted as a barrier to the wind. Sea state ranged as high as Beaufort 06 to 07 in open water on windy days making sightings difficult. These conditions were encountered most often in the southern and central Chukchi Sea in October.

Although the weather during most flights was good with unlimited visibility below the overcast, there were days (20 percent, n=80) when the weather was too poor to survey. Winds from the west or south generally produced acceptable weather, while winds from the east or north generally produced poor weather,



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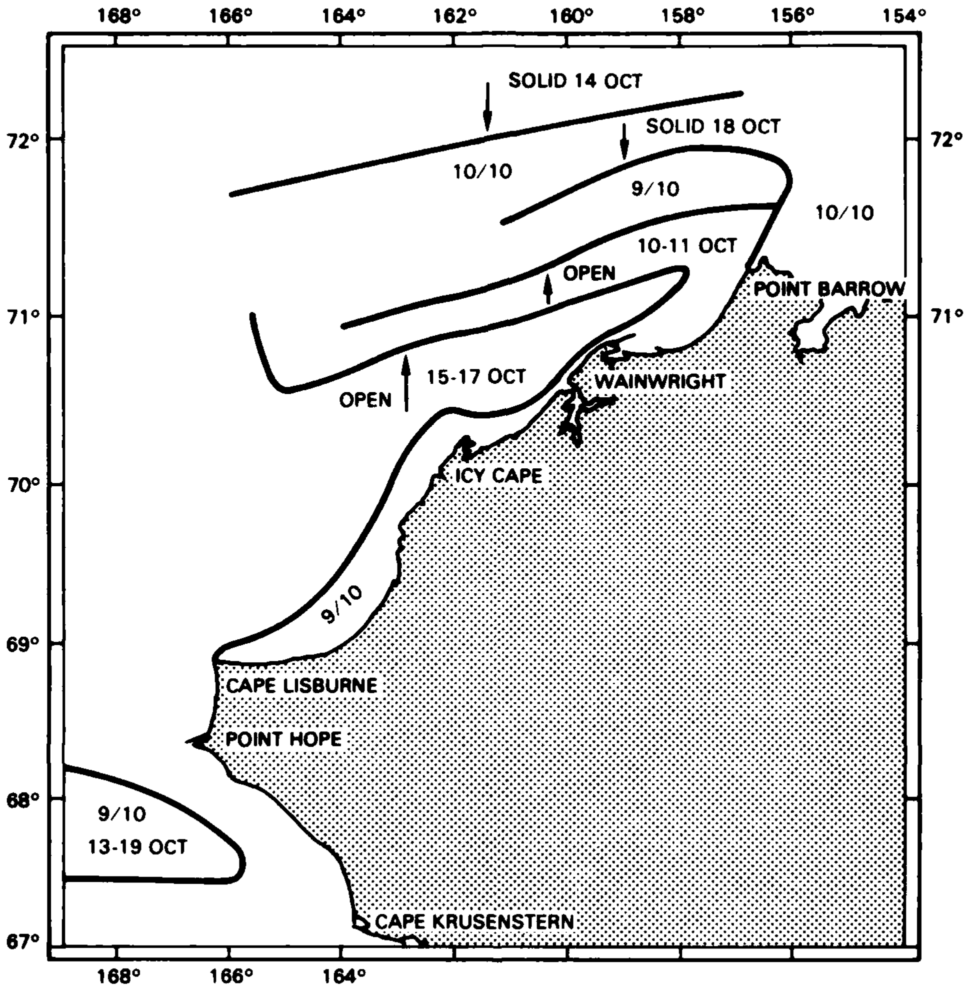

Figure 14. Schematic presentation of Chuckchi Sea ice conditions, October 1983.

including fog, which prevented flying. For example, extremely heavy and low fog existed over the water from 11 to 14 August when no surveys were flown.

Fog was the most common inclement weather encountered. Often transect legs were truncated when visibility was reduced to less than 1 km in heavy fog or when the ceiling descended below 122 m (400 ft). Surveys were less than 5 percent effective under these conditions and were thus an inefficient use of allocated aircraft time. Weather other than fog which prevented flying included rain and snow, high winds, and freezing drizzle or icing conditions.

Additionally, aircraft along the coast in support of geophysical boats or other coastal activity often necessitated moving or shortening some transect legs on poor

visibility days. When visual contact and separation was not possible, aircraft were kept clear of each other by altitude or geographic separatic.ı coordinated on a VHF r·· 'io safety channel.

Loss of available light hindered survey efforts in October. There were only nine hours of daylight on 1 October, and eight hours on 20 October. Darkness completely curtailed survey efforts on a transit from Kotzebue to Point Barrow on 13 October.

BOWHEAD WHALE

Distribution and Relative Abundance

One hundred sixteen sightings of 172 bowheads were made during the fall survey season (Figure 15). Bowheads were first found along the 140°W line approximately 130 km northeast of Demarcation Bay on 2 August. From 2 to 10 August, whales were consistently found in this same general area along the shelf break in water 48 to 2013 m deep. Affiliation with a specific ice type was not consistent. Whales were found up to 10 km into the 4/10 to 9/10 ice, or in open water on either side of the shifting ice edge. They seemed to exhibit site fidelity rather than ice preference.

Bowheads were distributed roughly between 0.5 km and 150 km from shore throughout September, though they were generally found nearer to shore during the latter half of September. For example, three whales were seen less than 0.5 km from shore off Point Barrow on 24 September. The heavy ice conditions, previously discussed, possibly accounted for fewer overall sightings this year when compared to 1981 and 1982. As in 1980, a heavy ice year, whales seen in the Beaufort Sea in September were usually swimming to the west and were very hard to resight once they dove under the ice.

The number of flights, total flight hours, number of bowheads, and the sightings per unit effort (SPUE) were calculated for each block by month (Table 13, Figure 16). As for the spring data, this method of calculating relative abundance is provided only as an index and should not be interpreted as a number indicative of absolute abundance. A calculation is provided in Appendix B of observed bowhead density throughout the survey area with comparisons to previous years.

In addition to calculated SPUE, the blocks were roughly classified bathymetrically as being shallow (< 50 m), transitional (50-2000 m), or deep

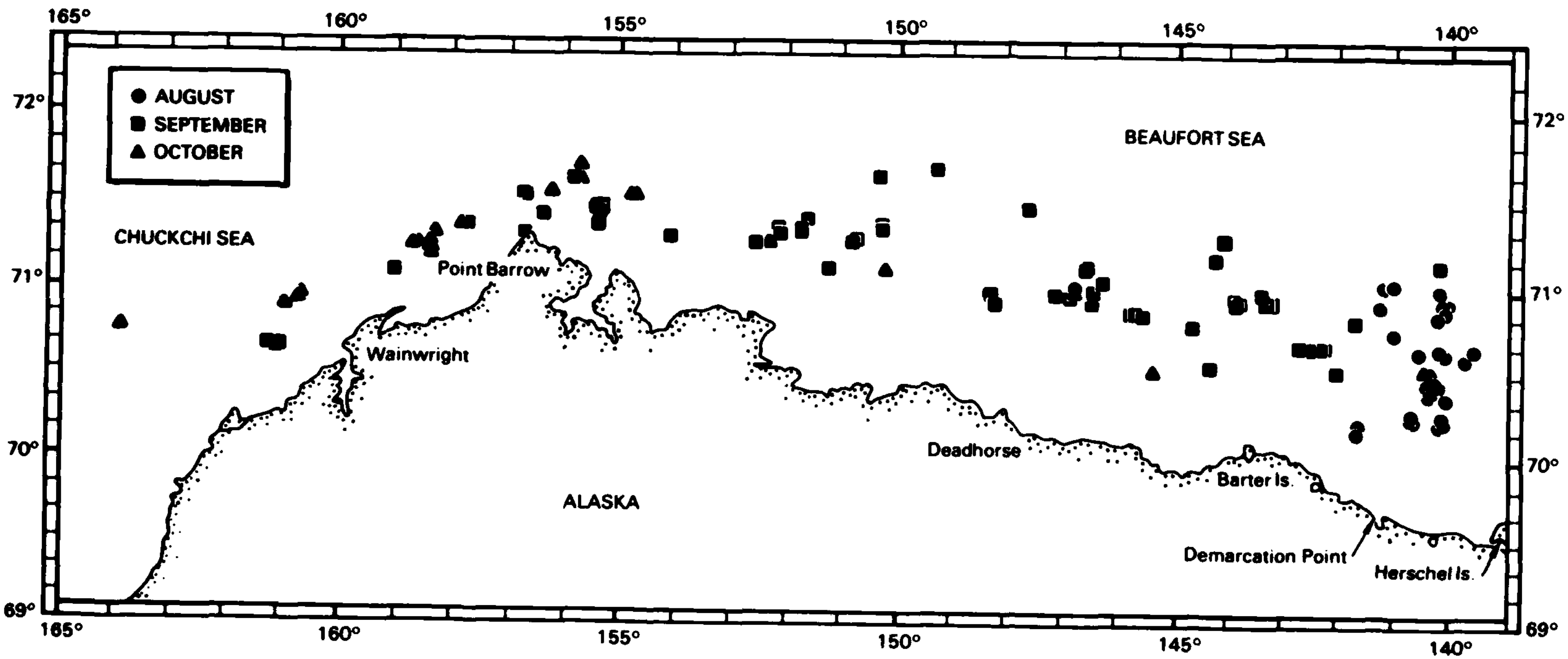

Figure 15. Distribution of 116 sightings representing 172 bowheads, fall 1983.

Table 13. Summary of effort, number of bowheads sighted and sightings per unit effort (SPUE, 1 hour survey) for each block by month, fall 1983.

Block No.	Depth 1 Regime	August Flts	August Hrs	August BH	August SPUE	September Flts	September Hrs	September BH	September SPUE	October Flts	October Hrs	October BH	October SPUE	Total Flts 2	Total Hrs 3	Total BH	Total SPUE
1	Shal	1	2.0	0	0	4	13.1	7	0.53	1	2.6	0	0	6	17.7	7	0.40
2	Tran	1	2.3	1	0.43	7	8.6	1	0.12	1	2.5	0	0	9	13.4	2	0.15
3	Shal	5	11.0	0	0	5	9.7	9	0.93	2	6.5	2	0.31	12	27.2	11	0.40
4	Shal	1	2.1	0	0	2	3.7	9	2.43	2	2.5	0	0	5	8.3	9	1.08
5	Shal	4	11.3	15	1.33	3	5.7	11	1.93	1	4.2	6	1.43	8	21.2	32	1.51
6	Tran	3	5.8	0	0	5	9.0	0	0	2	2.5	0	0	10	17.3	0	0
7	Tran	8	22.4	43	1.92	1	2.7	5	1.85	0	0	0	0	9	25.1	48	1.91
8	Deep	3	9.3	0	0	1	2.7	0	0	0	0	0	0	4	12.0	0	0
9	Deep	2	5.7	0	0	2	8.0	4	0.50	0	0	0	0	4	13.7	4	0.29
10	Deep	2	6.2	0	0	5	14.7	2	0.14	0	0	0	0	7	20.9	2	0.10
11	Tran	2	4.9	0	0	5	14.8	6	0.41	2	6.0	1	0.17	9	25.7	7	0.27
12	Shal	2	6.9	0	0	7	12.4	18	1.45	5	11.5	8	0.70	14	30.8	26	0.84
13	Shal	0	0	0	0	3	4.5	3	0.67	2	5.1	13	2.55	5	9.6	16	1.67
14	Tran	0	0	0	0	0	0	0	0	2	4.5	0	0	2	4.5	0	0
15	Tran	0	0	0	0	0	0	0	0	1	5.3	0	0	1	5.3	0	0
16	Tran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Shal	0	0	0	0	1	0.7	3	4.29	2	5.1	3	0.59	2	5.8	6	1.03
18	Tran	0	0	0	0	0	0	0	0	1	5.3	2	0.38	1	5.3	2	0.38
19	Tran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	Shal	0	0	0	0	0	0	0	0	1	3.1	0	0	1	3.1	0	0
21	Tran	0	0	0	0	0	0	0	0	1	3.1	0	0	1	3.1	0	0
22	Shal	0	0	0	0	0	0	0	0	1	3.1	0	0	1	3.1	0	0
Total Shallow		13	33.3	15	0.45	25	49.8	60	1.20	17	43.7	31	0.71	55	126.8	106	0.84
Total Transistion		14	35.4	44	1.24	18	35.1	12	0.34	10	29.2	4	0.14	42	99.7	60	0.60
Total Deep		7	21.2	0	0	8	25.4	6	0.24	0	0	0	0	15	46.6	6	0.13
Grand Total		34	89.9	59	0.66	50	110.3	78	0.71	27	72.9	35	0.48	111	273.1	172	0.63

1) Shallow = 50m, Transition = 50-2000m, Deep = 2000m
2) Total No. flights exceeds number of days flown since often several blocks were surveyed on one day
3) Total No. hours is less than reported elsewhere since this is actual survey time not total flight time

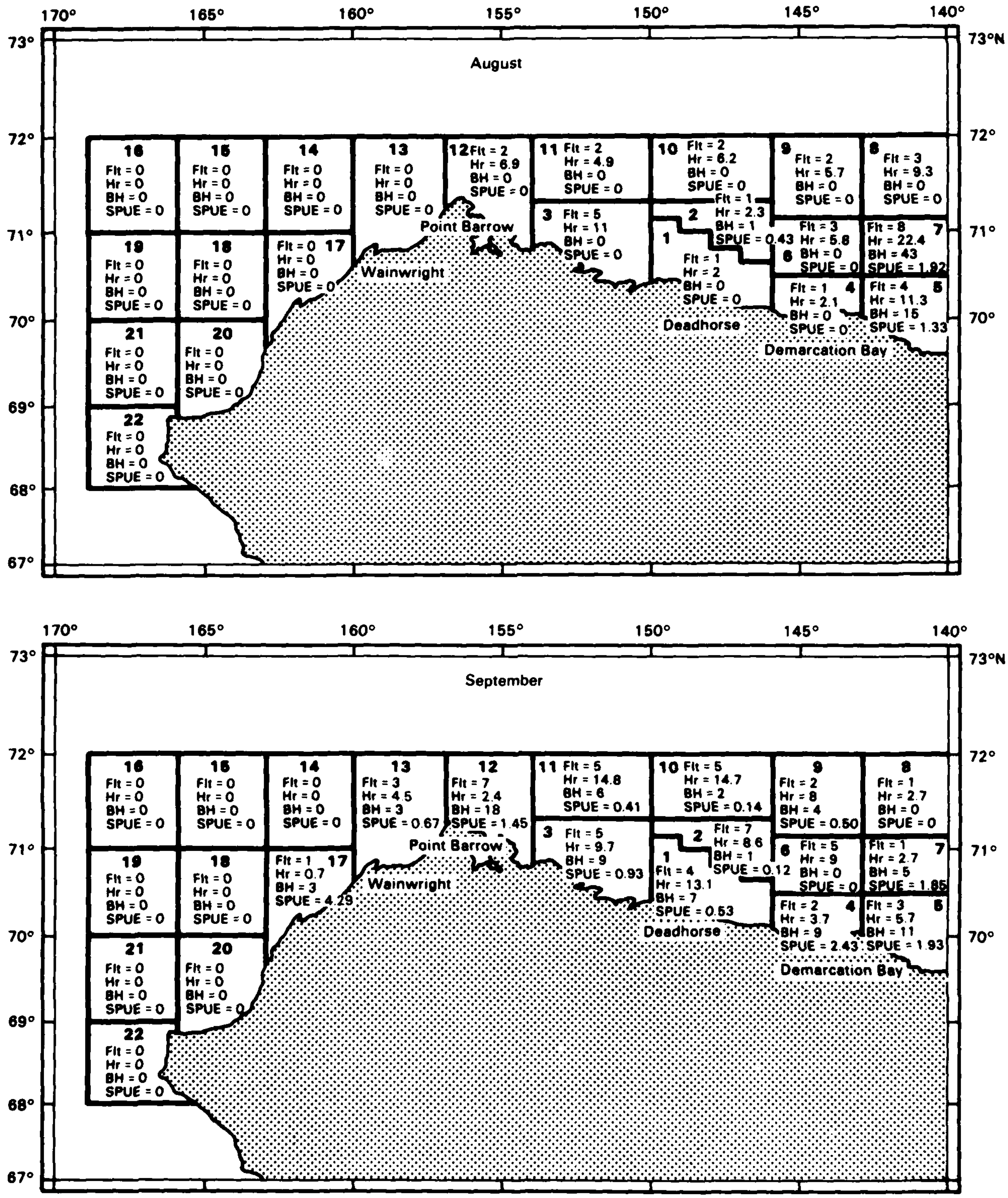

Figure 16. Relative abundance of bowheads in the Chukchi and Beaufort Sea survey blocks as calculated by sightings per unit effort (SPUE), fall 1983.

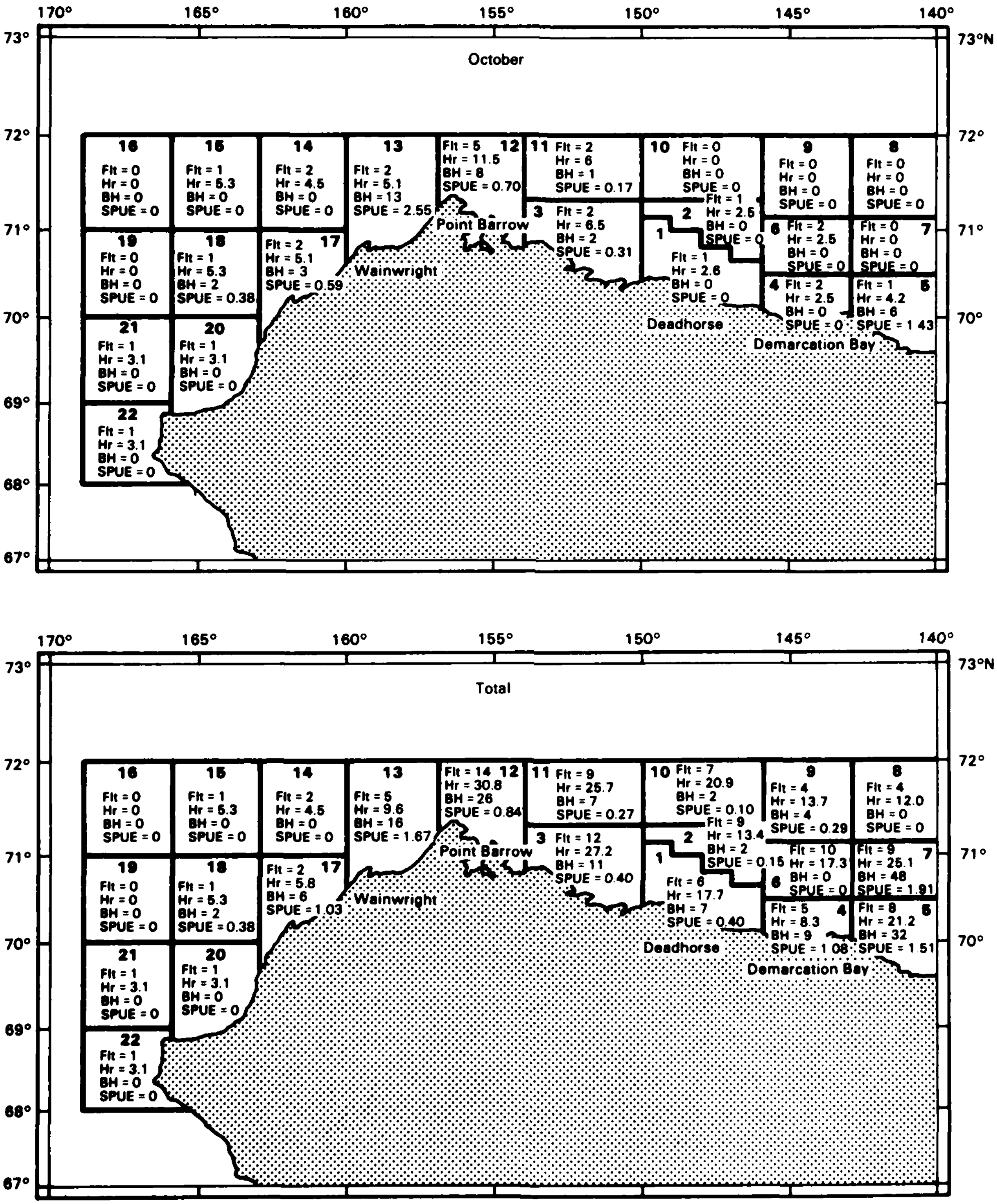

Figure 16. (Cont)

(> 2000 m) (Table 13). The highest bowhead SPUE in August occurred in blocks 5 and 7. In September SPUE was high in blocks 4, 5, 7, and 12. Blocks 5 and 13 had high SPUE in October. Overall blocks 4, 5, 7, 12, 13, and 17 all had relatively high SPUE.

Migration Timing and Habitat Relationships

The migration of bowheads across the Alaskan Beaufort Sea appeared to extend from 3 September to about 17 October although there were sightings as early as 2 August in the eastern Beaufort. The longitude at bowhead sightings was correlated more strongly with the date of sighting ($r^2 = 0.758$, $F=163.2$, $p \leq .001$) than with the depth ($r^2 = 0.351$, $F=15.9$, $p \leq .001$), or ice coverage ($r^2 = 0.060$, $F=8.3$, $p \leq .001$) at the sighting. The date was not strongly correlated with ice coverage ($r^2 = 0.308$, $F=44.9$, $p \leq .001$) nor depth ($r^2 = 0.197$, $F=14.8$, $p \leq .001$). This implies that the whale's location was determined more by temporal drives, than by depth or ice coverage.

Whales maintained headings in all directions in August and early September, but were strongly directed in late September and October (Figure 17). The first determined westerly movement of whales was observed on 3 September along the 71°N line. Nine whales were found in ponds and leads north of the more solid ice coverage. The whales maintained a westerly heading ($\bar{x}=218°$M, $z=3.57$, $n=6$, $p \leq .025$), disappearing under ice after about four to five blows at the surface. On 6 September five whales were found near 71°N between 140°W and 142°W heading south and west ($\bar{x}=200°$M). In late September bowheads held a predominantly westerly heading ($\bar{x}=221.3°$M, $z=21.2$, $n=38$, $p \leq .001$). In October, headings in the Beaufort Sea were clustered about the mean heading of 243°M ($z=11.3$, $n=20$, $p \leq .01$). Swimming speeds were subjectively estimated at between 2 and 4 km/h.

Bowhead sightings per unit effort (SPUE) were calculated by date for the fall season (Figure 18). There was no single peak migration period apparent, although SPUE was sporadically high in early August near the Canadian border, consistently high during the last two weeks of September along the Beaufort coast, and high again in the Chukchi Sea in early October. Whales were most commonly seen as individuals or in small groups of up to seven, usually in 6/10 to 9/10 ice coverage. There were no large aggregations of whales found, with the number of whales seen per survey ranging from 0 to 21 (5 August). This contrasts sharply with 1981 and 1982 when 40 and 159 whales, respectively, were seen on one survey, generally in

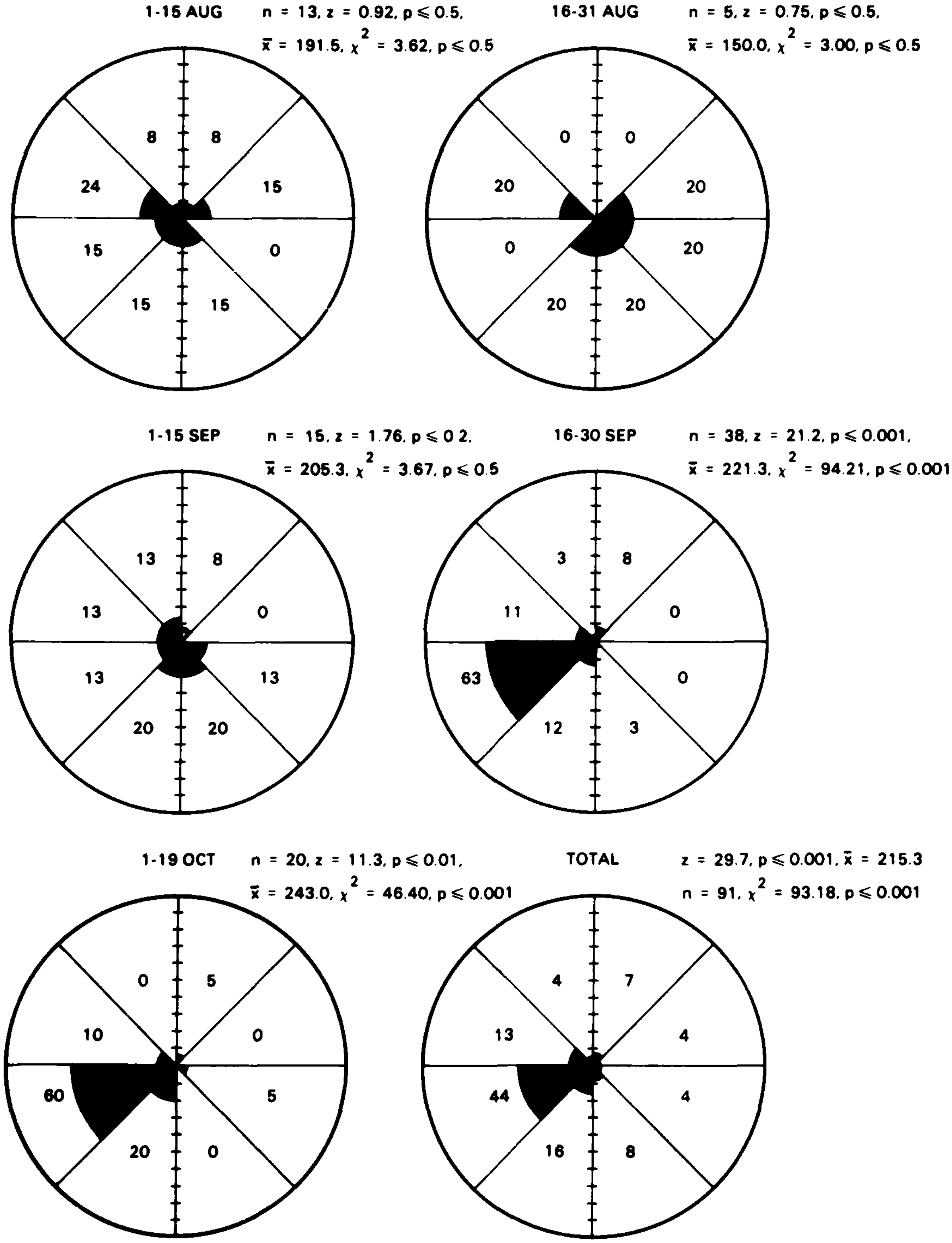

Figure 17. Direction of bowheads in the Beaufort and Chukchi Seas, fall 1983. Numbers within the pie diagrams are percentages.

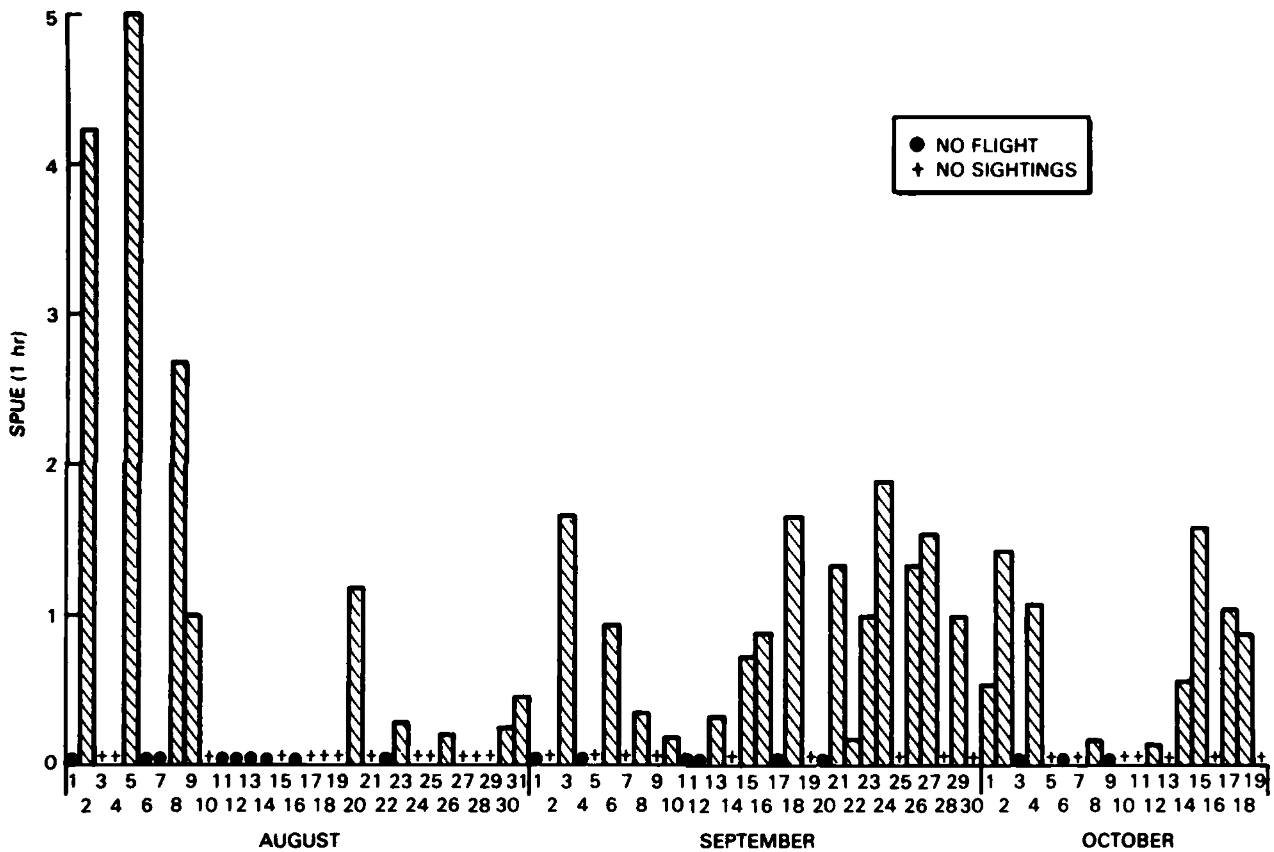

Figure 18. Bowhead sightings per unit effort (SPUE) by date, fall 1983.

relatively open water, during the latter half of September (Ljungblad et al, (a) 1982, 1983). Conversely, this season was reminiscent of 1980 when whales were seen as singles or in small groups in heavy ice (Ljungblad, 1981).

The relationship between ice coverage and the ability of observers to sight whales was tested via multiple regression analysis. Ice coverage had little effect on an observer's ability to see surfaced whales as determined by regression of tenths of ice on perpendicular sighting distance ($r^2 = 0.018$, $F = 0.1$, $n = 59$, $p \leq 0.50$). Whales were equally likely to be seen at all distances from the aircraft in all ice conditions encountered.

Bowheads were last seen in the Beaufort Sea in block 5 on 2 October, in block 3 on 8 October and in block 12 on 12 October. All were swimming at an estimated 1 to 3 km/h in a westerly direction. Bowheads were seen swimming southwest in block 13, the easternmost block in the Chukchi Sea, on 14, 17, and 18 October. A flight on 16 October indicated that the ice in block 12 was not yet solid and that bowheads could still be migrating from the Beaufort Sea. A flight on 18 October confirmed that the ice in block 12 was solid and bowheads could probably not migrate from the Beaufort Sea without the ice breaking up thereafter. It is believed therefore that the migration of bowheads from the Beaufort Sea ended on or before 17 October.

Twenty-four bowheads were seen in the Chukchi Sea between late September and mid-October. Four whales were seen on 24 September and two on 27 September, in blocks 13 and 17. Throughout October bowheads in the Chukchi Sea were seen at the edges of large (> 500 m) ponds, or in open water at the ice edge in blocks 13, 17, and 18. None were seen in small holes or cracks in the ice. Headings of bowheads in the Chukchi clustered about the mean of 222.9°M (Rayleigh $z=7.11$, $n=14$, $p \leq 0.001$). This mean heading is close to a predicted coastal course of 230°M derived from a line drawn from Point Barrow to Cape Lisburne.

The distribution and headings of bowheads seen in 1983 in the Chukchi Sea were quite similar to those found in 1982. A migratory pattern in which at least some bowheads swim around Point Barrow and then disperse southwestward across the Chukchi Sea would seem to be upheld by our 1983 data (see Figure 32). Braham et al, (1980) suggest that bowheads primarily follow the ice front west across the northern Chukchi Sea to Herald and Wrangel Islands before moving south and following the Chukotka peninsula south and through the Bering Strait. The data of the past two years suggest a more dispersed migration across the Chukchi Sea, at least for some whales in late September and October.

Bowheads were not consistently found with a particular ice coverage or type during the fall. There were some trends in bathymetric data, however (Table 14). Bowheads were seen in water from 10 m to almost 3000 m deep. All sightings were categorized bathymetrically as deep (over 2000 m), transitional (50 m to 2000 m) and shallow (less than 50 m). Bowheads were seen in deep or transitional depth zones in August and early September, and in shallow and transitional water in late September and October. This trend, with a shift to shallower sightings by late September, is similar to the pattern seen in 1982, though ice conditions were quite different.

Table 14. Number/percent of bowhead sightings in deep (over 2000 m), transitional (50 m - 2000 m) and shallow (less than 50 m) water, fall 1983.

Depth Regime	Aug 1-15	Aug 16-31	Sep 1-15	Sep 16-30	Oct 1-19	Total
Deep (over 2000 m)	2/4	5/50	4/16	0/0	0/0	11/6
Transition (50 m - 2000 m)	47/96	5/50	20/84	28/52	14/40	114/67
Shallow (less than 50 m)	0/0	0/0	0/0	26/48	21/60	47/27

The shift by bowheads from deep and transitional to shallow water regimes during the fall migration may be related to food availability. Observations of whales displaying possible feeding behavior along the migration route (Ljungblad et al, 1983) are the strongest indicator that the bowhead fall migration may be simply a westerly progression of whales that remain primarily interested in feeding. All animals observed possibly feeding have been seen nearshore in shallow water in the latter half of September and early October. We have no direct evidence of whales feeding in the deeper water areas where they are found in August and early September. A report by Schell et al (1982), summarizing food web and nutrient dynamics in nearshore Beaufort Sea waters, indicates that an area of relatively high primary production occurs in June and July offshore, roughly between the 50 m and 1000 m isobaths from 142°W to 146°W. This report also states that primary production is strongly influenced by the extent of ice cover and that it declines (with the decrease in light) after July. If a bloom of secondary producers (i.e., bowhead food) follows that of the primary producers sometime in July and August in this same area, bowheads seen there in August may be feeding.

As in Ljungblad et al (1983), we suggest that bowheads swimming around Point Barrow in the latter part of the spring migration (June) may swim no farther east than this (supposed) food site. When these food sources are reduced in availability in August and early September, they may be the first whales to move west and initiate the fall migration, or they may move toward shallower water near shore.

Calf Sightings and Estimated Recruitment

The gross annual recruitment rate (GARR = number of calves/total number of animals) was 13/172 or 7.56 percent (Table 15). The GARR per hour of survey was .00024, which is higher than in 1982 (.00019, Ljungblad et al, 1983). The GARR for the periods mid August to mid September, and the first half of October were high relative to early August and late September, indicating that some segregating of cow-calf groups may occur ($\chi^2 = 6.29$, df = 4, $p \leq 0.20$).

Calves were usually seen with their cows and other adults in ponds in medium to heavy ice coverage or along the ice/open water edge (Table 15). Some calves appeared light grey, mottled brown or tan. One calf photographed in August with its cow was estimated from the photo measurements to be 45 percent of the cows length.

On 10 September one calf was observed swimming on the surface near a submerged adult (visible subsurface). This calf appeared to have its mouth open with its rostrum protruded out of the water as it swam, though we do not know if this calf was attempting to feed. Durham (1980) reported evidence of mature baleen in six-month old calves.

Two cow-calf pairs were seen on 2 October. One pair was observed for approximately 1.5 h, a sonobuoy was dropped and many bowhead calls recorded. During this observation that calf spent nearly twice as much time at the surface as the cow. While at the surface the calf hung in the water tail down and sculling with its flippers. The cow repeatedly dove, then resurfaced near the calf while (apparently) emitting many calls.

The close association of calves (and maybe yearlings) to cows may be related to factors other than nursing. There may be a need to closely associate with adults to learn about the environment (Brodie, 1969). It is hypothesized that even if weaned at 5 months and about 6 m length (Nerini et al, 1983), the calf may stay with the cow at least until the end of the fall migration in the Bering Sea and possibly as a yearling into the next spring migration.

Table 15. Summary of bowhead calf sightings and estimated recruitment, fall 1983.

Period	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-19 Oct	Total
No. Sightings	25	7	19	41	24	116
No. Whales	49	10	24	54	35	172
No. Calves	2	1	3	3	4	13
*GARR (%)	4.08	10.00	12.50	5.56	11.43	7.56

Date	Flt	Lat. (N)	Long. (W)	Size Est. (M)	Grp. Size	Color	Heading (Mag.)	Behavior
9 Aug	31	70°12.7'	140°13.5'	4.6	4	-	-	Swimming very close to cow
10 Aug	32	70°12.3'	141°42.6'	4.6	2	mottled tan	240°	Dove
31 Aug	47	71°01.4'	141°15.0'	5.5	2	mottled brown	090°	Dove
3 Sep	49	70°56.0'	143°51.7	6.1	5**	mottled brown	270°	Swimming 8 km/hr, alone
3 Sep	49	70°57.7'	143°52.3'	6.7	5**	mottled dark brown	-	Attempted nursing
10 Sep	55	71°09.9'	140°13.6'	6.0	2	light grey	120°	Milling very close to cow
18 Sep	60	71°19.5'	151°44.7'	6.8	4	dark grey	240°	Swimming alone
21 Sep	62	71°02.5'	146°18.3'	-	2	-	200°	Swimming very close to cow
23 Sep	64	71°21.3'	150°19.5'	6.6	2	black	240°	Swimming alone
1 Oct	72	71°07.0'	150°13.2'	9.3	2	black	240°	Swimming near cow (possible juvenile)
2 Oct	73	70°30.4'	140°24.1'	-	3	-	240°	Swimming very close to cow
2 Oct	73	70°31.5'	140°29.8'	-	2	-	240°	Dove
17 Oct	85	70°44.6'	163°53.7'	-	2	-	320°	Close to ice

*GARR = number of calves/total number of animals
**Same Group

Behavior and Sound Production

Bowhead behavior, average group size, and apparent response to aircraft was summarized by two-week time period (Table 16). Not all sightings of whales offer equal opportunity to determine and define the behaviors observed, but some general comments can be made. The predominant behavior of bowheads throughout the fall was active swimming (58 percent). Bowheads were seen alone or in groups of from 2 to 7 ($\bar{x}$=2.60) whales between August and October. Average group size was the largest in early August (3.68) when several small groups of whales were encountered. These groups were engaged in social behaviors, including milling, touching and displaying. Displays seen included breaches, spy-hops, tail- and flipper-slaps, and underwater blows. A group of four whales was observed apparently feeding in water 62 m deep at 70°13'N, 140°14'W on 9 August. Several had mud on their rostrums. They often turned 180° upon surfacing and dove quickly as if they intended to feed again in the same area. With the exception of one cow-calf interaction, active swimming was the only behavior seen in late August.

Swimming and diving comprised the majority of behaviors noted throughout September, with combined trend toward these behaviors becoming more pronounced in the second half of the month (59 percent to 81 percent). The survey crews dedicated to monitoring bowhead-seismic vessel interaction and behavioral studies saw whales they believed to be feeding in late September approximately 7 km northeast of Barter Island and about 5 km northeast of Flaxman Island. Possible feeding was last noted in the Beaufort Sea on 8 October north of Harrison Bay at 71° 16'N, 152° 20'W.

Possible feeding was noted in the Chukchi Sea on 17 and 18 October at 71°14'N, 158°40'W and 71°12'N, 158°25'W, respectively. Groups of four to five mud-covered whales were observed turning back on the course they came from, flexing their tails in a deep dive contortion. They were in heavy ice (7/10 - 8/10 coverage) in 46 m deep water. Other behaviors seen in October included swimming and diving (51 percent) and cow-calf interactions (17 percent).

Animals involved in prolonged aerial displays were noted several times in fall. On 6 September a medium-sized whale was observed for 16 minutes while it repeatedly interspersed breaching with tail- and flipper-slaps, underwater blows, and spy-hops. Another medium-sized whale was observed swimming past the first whale 100 m away without apparent change in speed, direction or, overt behavior. A similar display was seen on 18 September when a medium sized whale was

Table 16. Summary of bowhead behavior, response to aircraft, and average group size, fall 1983. No. (%) = Number (Percent)

PERIOD / Behavior*	AUG 1-15 No.(%)	AUG 16-31 No.(%)	SEP 1-15 No.(%)	SEP 16-30 No.(%)	OCT 1-19 No.(%)	TOTAL No.(%)
SWIM	27(55)	8(80)	10(42)	39(72)	17(48)	101(58)
DIVE	2(4)	0(0)	4(17)	5(9)	1(3)	12(7)
COW-CALF	0(0)	2(20)	2(8)	2(4)	6(17)	12(7)
REST	8(16)	0(0)	5(21)	1(2)	2(6)	16(9)
FEED	4(8)	0(0)	0(0)	0(0)	7(20)	11(6)
UNDERWATER BLOW	5(10)	0(0)	0(0)	0(0)	0(0)	5(3)
TAIL-SLAP	0(0)	0(0)	1(4)	4(7)	2(6)	7(5)
SPY-HOP	2(4)	0(0)	2(8)	0(0)	0(0)	4(2)
BREACH	1(2)	0(0)	0(0)	2(4)	0(0)	3(2)
ROLL	0(0)	0(0)	0(0)	1(2)	0(0)	1(1)
TOTAL	49(100)	10(100)	24(100)	54(100)	35(100)	172(100)
Response to Aircraft*						
NO	24(49)	3(30)	21(88)	45(83)	32(91	125(73)
YES	25(51)	7(70)	3(12)	9(17)	3(9)	47(27)
	$\bar{x} \pm sd$ (n)	$\bar{x} \pm sd$ (n)	$\bar{x} \pm sd$ (n)	$\bar{x} \pm sd$ (n)	$\bar{x} + sd$ (n)	$\bar{x} \pm sd$ (n)
Average Group Size	3.68 ± 1.0 (9)	2.50 ± 0.71 (2)	2.25 ± 0.5 (4)	2.30 ± 0.67 (10)	2.10 ± 0.32 (10)	2.60 ± 0.91 (35)

*See pg. 9 - 10
(n) = number of groups of two or more whales

observed tail-slapping for 17 minutes, interspersing tail-slaps with breaches, flipper-slaps and head lunges (partial breach). Six other whales were seen within 500 m of the displaying whale. Four of the six appeared to be swimming past the displaying whale, and two maintained headings that would appear to take them toward the displaying animal.

Incidents in which displaying bowheads were not near other whales were noted on 16 September, 24 September, and 2 October. On 16 September an individual breached five times at about 47 second intervals while apparently heading generally west. The nearest whale sighted was 3 km away and apparently unaffected by the display. On 24 September and 2 October lone bowheads were observed tail-slapping for 10 minutes and 7 minutes, respectively. Nearest whales were 1 km and 5 km away on these dates and also appeared unaffected by the display.

Overall 27 percent of bowheads seen in fall 1983 appeared to respond to the aircraft (Table 16). Potential responses were seen most often in August, least often in October. The whales that appeared to respond to the aircraft in August were found in lighter ice coverage ($\bar{x}$=4.64 tenths, s.d.=3.11) than whales that did not respond to the aircraft ($\bar{x}$=7.78 tenths, s.d.=3.32,$F(1,27)=6.41, p \leq .05$), but there was no significant difference in response related to depth at sighting ($t = 0.36$, df = 31 $p \leq 0.50$). There was no significant difference in observed response in September or October, due to ice coverage or depth ($t = 1.07$, df = 77, $p \leq 0.40$; $t = 1.19$, df = 34, $p \leq 0.40$).

The response to aircraft data was also examined relative to the concurrent general behavior observed (Table 17). Resting whales were observed to respond most to the aircraft. This may be because reactions by quiescent whales were so noticeable. Conversely, reactions by relatively active whales, those feeding, displaying or engaging in social interactions, may be more difficult to discern due to the higher relative level of activity.

Huddling, defined as a group of whales lying at the surface with their heads close together, was seen twice on 5 August. Each time a group of five whales, very near to the ice edge, exhibited this group behavior, possibly in response to the aircraft which maintained an altitude of 305 to 460 m throughout the observations. Similar huddling or "clustering" behavior was seen twice in August, 1982 and thought to be a response to low aircraft pass during a sonobuoy drop, and a

Table 17. Number/percent of bowheads that appeared to respond to the aircraft relative to concurrent general behavior observed.

Behavior	Positive Reaction No.(Percent)	Negative Reaction No.(Percent)	Total No.(Percent)
REST	4(44)	5(56)	9(100)
MIGRATE	15(19)	63(81)	78(100)
DISPLAY	2(13)	13(87)	15(100)
FEED	1(12)	7(88)	8(100)
SOCIAL	1(16)	5(84)	6(100)
TOTAL	23(20.5)	93(79.5)	116(100)

"clustering" around a calf (Ljungblad et al, 1983). In all cases, bowheads were initially seen at the surface separated by 100 to 500 m. Within five minutes of the approach of the aircraft the whales coalesced with their heads nearly touching either laterally or rostrum to rostrum.

Huddling was also seen twice in September 1982, once approximately 0.5 h after a seismic boat began airgun shooting (14 September), and once when no seismic sounds were heard (24 September) (Reeves et al, 1984). It was suggested that huddling **might** have been a response to the presence or onset of loud sounds.

The survey aircraft at 610 m has measured peak noise levels of 80 to 100 dB in the 15 to 500 Hz frequency band (Moore et al, 1984). These levels represent sound that is approximately 34 to 38 dB above measured ambient noise levels. Precise sound level at the whale can not be calculated, however, without knowing the orientation (angle and altitude) of the aircraft relative to the whale (Urick, 1972). Neither is there any definitve information available on bowhead hearing capabilities to allow conclusions regarding noise-induced behaviors based upon the probability of the whale being able to hear specific sounds (Norris and Leatherwood, 1981). Therefore, it is speculative to assume huddling is a bowhead response to a novel loud acoustic stimulus, though qualitative observations might suggest such an association. At present it is simply an unusual behavior that has been noted in two consecutive years under variable circumstances.

Sonobuoys were dropped sixteen times in the Beaufort Sea and twice in the Chukchi Sea to record bowhead sounds and to determine the presence of geophysical sounds (Table 18). Few sounds were recorded on most drops and whales were rarely resighted for concurrent visual observation, thus most recording sessions were short. The exception was 2 October 1983 when a sonobuoy was dropped near five bowheads including two cow-calf pairs and 88 percent (n=775) of our sound sample was recorded.

Bowhead calls were aurally analyzed as in the spring and placed into simple or complex moan categories (Table 19). Of a sound sample containing 775 discrete calls, 65 percent were simple and 35 percent were complex moans. The constraints on concurrent behavioral observations mentioned with the spring sound sample apply here. Thus, the specific biological significance of these sounds is all but impossible to interpret at this time. Although no significant correlations were found when a calculated behavioral index (see p. 29) was regressed with call rate and call ratios, differential production of identified call types and call rate (Table 19) may be very generally associated with behavior. Overall, more complex ("growls" and "trumpet") calls were recorded near whales that were mildly socializing (within a body length) or actively socializing (body contact) than near those whales noted as swimming only. Swimming whales appeared to produce many simple (FM) moans with fewer complex (AM) calls. For example, on 2 August, 79 percent (n=28) of all calls recorded near three social whales were complex "growls" and "trumpets" with the remaining calls high FM_5 calls that often are associated with the high frequency, rasp-like AM_2 trumpet calls. Similarily, on 9 August and 21 September, 75 percent (n=4) and 67 percent (n=24) of all calls recorded near a mildly social group and a cow-calf pair were complex, respectively. Conversely, on 26 September when two whales were noted as swimming only, 85 percent (n=13) of the calls recorded were simple moans with 62 percent of these being "up" calls. Associations such as these are similar to those reported in Würsig et al (1982) and Ljungblad et al (1983).

The sound sample recorded on 2 October near five bowheads, including two cow-calf pairs, provided the most diverse sound sample. These sounds were recorded over an 88 minute period when nearly continuous visual observation of one of the cow-calf pairs was possible. The pair remained in the same area for the entire period with the calf remaining at the surface nearly motionless as the cow repeatedly dove and resurfaced near the calf. We cannot be sure which of the five

Table 18. Location and recorded subject of sonobuoy drops, fall 1983.

Flt	Date	Location		Subject Species	Incidental Recording
26	2 Aug	70°34.9'	139°40.0'	Bowhead	Seismic Sounds
31	9 Aug	70°13.0'	140°10.7'	Bowhead	Seismic Sounds
32	10 Aug	70°11.6'	141°48.0'	Bowhead	Seismic Sounds
41	25 Aug	71°38.5'	148°22.2'	Belukha	Belukhas Distant Seismic
42	26 Aug	71°03.6'	146°45.4'	Bowhead	Ambient
44	28 Aug	71°50.8'	150°33.2'	Belukha	Ambient
49	3 Sep	71°04.9'	144°23.7'	Bowhead	Ambient
51	6 Sep	70°40.6'	142°17.9'	Bowhead	Ambient
62	21 Sep	71°02.3'	146°18.6'	Belukha/ Bowhead	Bowhead/ Belukha
64	23 Sep	71°16.9'	150°47.7'	Bowhead	Ambient
65	24 Sep	70°39.5'	161°18.9'	Bowhead	Ambient
67	26 Sep	71°30.8'	156°44.9'	Belukha/ Bowhead	Bowhead/ Belukha
73	2 Oct	70°31.0'	140°27.6'	Bowhead	Bowhead
73	2 Oct	70°30.8'	145°25.3'	Bowhead	Bowhead
74	4 Oct	71°33.2'	154°48.9'	Bowhead	Ambient
78	10 Oct	71°24.2'	157°18.9'	None	Ambient
81	13 Oct	68°12.6'	166°37.4'	Gray	Ambient
82	14 Oct	71°19.5'	158°20.2'	Bowhead	Ambient

Table 19. Results of initial aural analysis of bowhead calls recorded in fall 1983. No.(%) = Number (percent).

	Sample					Simple				Complex					
	Duration	Number	Call	General	Behavior	Up	Down	Const.	Inflect.	High	Growl	Trumpet	Total		
Date	Minutes	Whales	Rate	Behavior	Index	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.	Noise	Comment
2 Aug	10"	3	0.93	2 Social, Display 1 Swim	3.3					6(21)	14(50)	8(29)	28		1 Whale of pair spy hops four times
9 Aug	11"	6	0.06	2 Social, Swim	1.6					1(25)	3(75)		4	Airgun Faint Aircraft	Small sample of bowhead sounds
21 Sep	16"	2	0.75	Social, Nurture	4.0	3(12)	5(21)				16(67)		24	Faint Aircraft	Cow-calf bowhead (1 Pair) Belukha sounds possibly "masking" bowhead sounds
26 Sep	6"	2	1.08	Swim	1.0	8(62)	2(15)		1(8)		2(15)		13	Faint Aircraft	Faint belukha
2 Oct	88"	5	1.55	Social, Nurture, Swim	3.4	184(27)	104(15)	6(1)	156(23)	8(1)	203(30)	23(3)	684	Aircraft	Cow-calf bowhead (2 Pair) Gulp-like sounds = 'growls'
14 Oct	4.5"	3	1.62	2 Social, Display	3.3	6(27)	6(27)		5(23)		5(23)		22	Aircraft	
TOTAL	135.5"					201(26)	117(15)	6(1)	162(21)	15(2)	243(31)	31(4)	775		

whales in the area were producing the calls recorded though we assume at least some of the calls were produced by the cow-calf pair being observed.

Two intriguing results of the aural analysis of these sounds are: (a) the FM_1 "up" (n = 184) calls were almost always louder than any other calls recorded and often ended in a trumpet-like rasp, and (b) several moan sequences could be identified. The fact that the FM_1 calls were consistently louder than all other recorded calls is interesting, particularly when compared to results presented in Würsig et al (1983) that describe a recording made in similar circumstances in the Canadian Beaufort Sea, August 1982. On that occasion many "loud low FM calls" were recorded near a mother-calf pair as they moved apart and together over a 40 minute period with the calf alone at the surface for extended periods ($\geqslant$ 10 min). We do not know what function "loudness" might serve in cow-calf interactions but it is notable that this feature stood out in both recordings. The moan sequences recorded on 2 October were unlike the repetitive "up" moan sequence recorded in spring (2 May), nor were they similar to the sequential moans described in Ljungblad et al, (a)1982. Ninety-five percent (n=684) of the calls recorded on 2 October fell into "up," "down," "inflect," or "growl" categories (Table 19). It should be noted that the "down" moans were the least represented of the four categories, and that "inflect" moans contain all sounds that change frequency direction no matter where or how many times this occurs in the sound (i.e., a grab bag category). The sequences noted were the following:

- In the first 12 minutes of tape, 21 calls were counted, 70 percent of which were a paired or (sometimes) triplet sequence of relatively loud "up" calls. Seventy-five percent of such paired/triplet "up" sequences (n=15) were followed by one or more "growls" (i.e., FM_1 -FM_1 -AM_1). Such "up" sequences were less frequent (n=7) in the remaining 28 minutes of tape so analysed, but were similar where they occurred.
- "Inflect" calls given in sequences 2 to 5 calls long were common 12 minutes to 40 minutes into the tape. The last "inflect" call of a series often ended in a "gulp-like" sound (counted as a "growl") during a short (5 minutes) segment about 25 minutes into the tape (i.e., FM_4 - FM_4 -FM_4 -AM_1).

These sequences may be further quantified, and perhaps other sequences identified, with a more rigorous analysis of the tape.

OTHER SPECIES

Gray Whales

On 17 August, 13 gray whales were observed at 71°26.6'N, 156°11.5'W just north of Point Barrow in open water. One calf was among this feeding group. They were within 1 km of ice in less than 11 m deep water. On 27 August a single gray whale was seen near there at 71°28.6'N, 156°11.3'W in heavy (9/10) ice. It dove and was not resighted. On 27 September two gray whales were seen southwest of Point Barrow. These whales were in 8/10 ice and were not resighted.

Gray whales were seen along the Chukchi Sea coast in October. Mud plumes and varied headings indicated that most whales were feeding. Five were seen in Ledyard Bay and five south of Point Hope on 13 October. Their migration route from Point Hope to the Bering Strait may have been direct as no other gray whales were found along the coast between Point Hope and Kotzebue.

Belukha Whales

Belukhas were seen near bowheads in early August, though by late August and throughout September they were usually seen north and west of the bowheads and often sighted in water over 600 m deep (Figure 8). The observed fall distribution of belukha whales around Point Barrow is closer to the land than in the spring (Figure 8), though not as close as the fall bowhead route. They remain 75 km offshore until about the 154° W where they turn southwest past Point Barrow and into the Chukchi Sea. Their distribution in the Chukchi Sea apparently broadens as they move south, though there were few sightings in 1983.

In August and September belukhas were seen in groups of 15 to 200 swimming westerly (χ^2=16.15, df=7, n=46, p<.025). Behavior was almost exclusively migrational with only 5 percent of all animals seen resting. Approximately 14 percent (n=328) of all sightings involved apparent nursing behavior by immature belukhas. Cow-immature pairs appeared to group and segregate themselves from the rest of the population. On 24 August active nursing was seen in two cow-calf pairs. Milk was seen in the water and the calf was swimming slowly under the cow. On 28 August, four cow-immature pairs were noted swimming below the surface. The immature whale would leave the cow to surface and breathe, then would return to swim under the cow. Another example of immature segregation was a group of 31 belukhas seen on 5 September, 15 of which were calves or small juveniles. Conversely, a group comprised only of large, all white adults was seen on

10 October just west of Point Barrow. In mid-October belukhas were observed churning water in holes in over 99 percent ice coverage keeping them open to breathe.

Pinnipeds

Bearded seals, ringed seals and unidentified pinnipeds were seen throughout the survey area, especially near Harrison and Smith Bays. Late in the day pinnipeds were sighted as often hauled out on the ice as swimming in the water. Most responded to the aircraft whether on ice or in the water resulting in many seals going unidentified. One ribbon seal was seen on 29 August at 71°41.2'N, 152°40.7'W in block 11.

Walruses were commonly seen in groups in the open water or on ice floes generally near Point Barrow in September. Walruses were also sighted along the coast and in water over 165 m deep. One was seen as far east as north of Barter Island on 6 September (Table 20). In October, walruses were found usually in mother-pup pairs in shallow, coastal open water or in large groups on ice floes.

Polar Bears.

Polar bears were seen generally offshore on the ice in August and September (Table 21). Most polar bears were seen alone, usually running across the ice (probably) in response to aircraft noise. Two unusual sightings were a group of five polar bears on 9 September, and a group of 19 polar bears on 26 September gathered at what appeared to be a kill site. The group of 19 included six cubs. All bears appeared loosely aggregated (within 0.5 km) around a central area of blood-stained ice. In both cases the remains of the prey animals were not identified.

Polar bears were seen in clumped distribution offshore in the Beaufort Sea in October on older, larger pieces of pan ice. They were also seen throughout the ice in the Chukchi Sea.

Table 20. Summary of walrus sightings, fall 1983.

(*Approximate position of large aggregation)

Date	Flt	Estimated Number	Latitude (N)	Longitude (W)
17 Aug	34	35	71°49.7'	156°43.7'
27 Aug	43	1	71°19.7'	153°46.8'
		17	71°27.3'	156°12.7'
		2	71°22.3'	156°27.5'
29 Aug	45	7	71°36.0'	152°44.7'
5 Sep	50	1	71°25.1'	154°22.7'
		1	71°20.7'	155°14.9'
		1	71°28.5'	155°33.4'
6 Sep	51	1	70°12.1'	143°31.5'
9 Sep	54	1	71°10.1'	150°33.5'
15 Sep	58	141	71°40.0' *	153°20.0'
18 Sep	60	140	71°38.0' *	153°55.0'
24 Sep	65	55	71°20.0' *	156°40.0'
		350	70°40.0' *	161°10.0'
25 Sep	66	56	71°15.0'	156°45.0'
26 Sep	67	20	71°32.3'	156°22.4'
27 Sep	68	129	71°20.0' *	157°00.0'
8 Oct	77	3	71°25.5'	156°32.3'
10 Oct	78	1	71°12.0'	161°06.2'
		2	71°10.7'	161°21.0'
		1	71°05.9'	162°18.5'
		1	70°49.5'	161°39.5'
11 Oct	79	2	71°21.0'	156°42.8'
		1	70°42.7'	160°08.3'
		1	70°02.7'	163°52.2'
		2	70°04.9'	163°51.0'
		1	70°27.4'	163°43.7'
		2	71°12.6'	163°34.0'
		1	71°36.4'	163°14.1'
		1	71°32.9'	163°13.3'
		1	71°31.9'	163°12.7'
		1	71°06.3'	163°11.4'
		2	71°02.9'	162°38.0'
		1	71°25.5'	162°35.4'
13 Oct	81	3	68°52.9'	165°25.7'
		1	68°52.9'	165°50.7'
		25	68°52.6'	166°14.8'
		1	68°52.3'	167°14.8'
		2	68°41.0'	166°16.0'
		4	68°40.6'	166°10.8'
		7	68°37.6'	166°13.9'
		2	68°35.7'	166°15.5'
		2	68°38.7'	168°40.5'

Table 20 (cont). Summary of walrus sightings, fall 1983.

(*Approximate position of large aggregation)

Date	Flt	Estimated Number	Latitude (N)	Longitude (W)
13 Oct	81	2	68°25.1'	166°20.9'
		1	68°24.0'	166°27.2'
		5	68°22.5'	166°38.2'
		1	68°21.4'	166°45.4'
		3	68°19.4'	166°46.6'
		6	68°18.8'	166°36.4'
		200	68°11.5' *	168°20.0'
		125	68°10.9' *	168°28.2'
		165	68°10.4' *	168°38.6'
		400	68°06.9' *	168°49.8'
		120	68°03.6' *	168°49.3'
		120	68°00.3' *	168°38.9'
		150	68°01.8' *	168°26.3'
		150	68°00.6' *	168°12.9'
		2	69°20.1'	166°57.8'
15 Oct	83	25	71°02.4'	157°20.2'
		42	70°59.8'	161°17.4'
		30	70°58.8'	162°11.9'
		8	71°23.5'	157°25.8'
17 Oct	85	1	71°19.3'	157°16.9'
		1	70°37.8'	163°12.6'
		2	70°36.3'	164°15.5'
		2	70°35.4'	164°15.4'
		1	70°06.7'	165°04.0'
		1	69°59.6'	165°34.5'
		1	70°54.1'	165°31.9'
		1	70°58.7'	165°31.4'
19 Oct	87	1	69°47.6'	165°04.8'
		2	69°02.0'	165°50.2'
		1	70°00.0'	165°51.5'

Table 21. Summary of polar bear sightings, fall 1983.

Date	Flt	No.	Latitude	Longitude	Type
18 Aug	35	2	71°59.4'	142°49.4'	Adult-Juvenile
27 Aug	43	1	71°09.7'	152°40.3'	Adult
29 Aug	45	1	71°53.2'	153°40.3'	Adult
2 Sep	48	1	71°07.7'	148°54.5'	Adult
8 Sep	53	1	70°57.0'	148°32.3'	Adult
9 Sep	54	1	71°10.9'	150°24.5'	Adult
		5	71°16.5'	153°38.9'	Adult
15 Sep	58	1	71°33.7'	150°19.6'	Adult
		1	71°34.2'	150°30.9'	Adult
		1	71°57.4'	153°53.0'	Adult
16 Sep	59	1	70°30.5'	146°57.4'	Adult
18 Sep	60	1	70°59.4'	149°31.4'	Adult
		1	70°59.4'	149°43.7'	Adult
21 Sep	62	1	70°38.6'	146°34.8'	Adult
22 Sep	63	1	71°13.5'	148°16.3'	Adult
		1	71°11.3'	148°16.1'	Adult
23 Sep	64	1	71°08.0'	150°21.8'	Adult
24 Sep	65	1	71°46.8'	156°15.1'	Adult
		1	71°22.8'	158°15.1'	Adult
		1	71°16.4'	158°40.2'	Juvenile
		2	71°08.8'	157°30.7'	Adult-Cub
26 Sep	67	19	71°19.2'	154°09.8'	Adult-Cubs
		1	71°31.0'	156°48.8'	Adult
27 Sep	68	3	70°55.3'	159°37.8'	Adult-Cubs
4 Oct	74	1	71°32.9'	150°40.3'	Adult
7 Oct	76	1	71°16.1'	146°49.3'	Adult
		1	71°20.5'	148°39.2'	Adult
11 Oct	79	2	71°18.4'	163°34.2'	Adult-Cub
		2	71°41.0'	163°30.7'	Adult-Cub
		1	71°42.8'	163°32.4'	Adult
		1	72°01.1'	163°23.9'	Adult
13 Oct	81	3	67°35.5'	166°16.8'	Adult-Cubs
14 Oct	82	1	71°02.3'	163°04.3'	Adult
		1	71°15.7'	164°13.0'	Adult
		1	71°08.3'	164°46.8'	Adult
		1	71°02.9'	164°47.9'	Adult
17 Oct	85	3	71°14.2'	158°41.6'	Juveniles
		1	71°07.1'	161°31.7'	Adult
		6	71°02.9'	162°30.2'	Adults
		1	70°45.7'	164°47.1'	Adult
		1	71°16.1'	159°28.6'	Adult
18 Oct	86	1	71°39.3'	160°11.6'	Adult
		1	71°15.0'	157°54.3'	Adult
19 Oct	87	3	70°46.6'	159°50.4'	Adults

CONCLUSIONS

a five-year review

This section represents an effort to review and synthesize data gathered on aerial surveys of endangered whales conducted between 1979 and 1983 and funded by MMS. Each year's efforts and results have appeared separately in annual reports finalized as NOSC technical documents (Ljungblad, 1981; Ljungblad et al, 1980, (a) 1982, 1983). The methods of data collection and analysis have remained similar throughout all years with the principal exception of the use of a microcomputer aboard the aircraft since 1982 to record and, later, analyse data. The objectives of the study, too, have remained similar over the years, though flight effort has varied somewhat each year with MMS requirements and input from the expanding data base. Variations in flight effort from year to year sometimes made it difficult to compare the data between years.

Bowhead and gray whales have been the principal species studied over the years due to their endangered status, and are the only species addressed in this review. Sightings of all other marine mammals may be referenced in the annual reports. This review follows the general season/species format of the field season efforts: spring/bowhead, summer/gray whale, fall/bowhead. Retaining this format resulted in 55 flights being excluded from review including: 26 flights in the Beaufort Sea June and July 1980, with 16 bowheads seen in June; nine flights in the Bering Sea October and November 1980, with 256 gray whales seen; 20 flights in the Bering Sea May, June, and August 1981, with 336 gray whales seen. The objectives for each season are briefly stated prior to presentation of the summary data.

Spring (April, May)

BOWHEAD WHALE

The primary objectives of spring aerial surveys have been to determine the distribution and timing of the bowhead migration, and to derive relative and/or absolute abundance estimates in or near proposed or existing federal lease areas. Bowhead behavior and sound production have been summarily recorded in association with these efforts.

Distribution and Density

There were 891 sightings of 2605 bowheads made over the five spring seasons (Figure 19). Bowhead spring distribution generally corresponds to open water areas that develop annually during ice breakup. The areas usually are southeast and north of St. Lawrence Island, north and south of Cape Prince of Wales, the nearshore lead stretching off the coast between Point Hope and Point Barrow (see Figure 2), and an easterly directed lead stretching roughly along the 71°30'N line between Point Barrow and approximately 152°W. The plotted distribution corresponds very well with that reported in Braham et al, (1980) for spring bowhead sighting data collected between 1974 and 1979.

Observed bowhead densities in spring also reflect that whales are found in greatest abundance in those areas of relatively open water along the migration route (Figure 20). Highest densities compiled over five seasons have been calculated for regions* north of St. Lawrence Island, north of Cape Prince of Wales and northeast of Point Barrow.

The distribution and observed densities of bowheads in the Beaufort Sea reflects a migration route that is approximately 25 km wide at Point Barrow, broadening to about 50 km north of Smith Bay and extending east to Harrison Bay. A predicted 50 to 100 km wide migration corridor east of 150°W to the U.S.-Canadian border is based on about 7 percent of all sightings, as ice is usually very heavy ($>9/10$) there resulting in few whale sightings. Notably, no whales have been seen in or near existing or proposed Beaufort Sea federal lease areas as these areas usually remain covered by shorefast ice through May.

Migration Timing and Habitat Relationships

In spring bowheads migrate through restricted open water areas in predominantly ice covered seas. Whales seen in the Bering and Chukchi Seas maintained primarily northerly headings, though no significant clustering was found ($X^2 = 8.12$, $n = 109$, $p \leq 0.3$; Figure 21). Bowheads seen northeast and east of Point Barrow in the Beaufort Sea were significantly clustered about a mean of 059.1° magnetic, and 94 percent of all whales were within 30° of due east.

The timing of the northward migration appears to be regulated in part by the seasonal breakup of the sea ice. In 1980, ice remained heavy in the southern

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*Regions depicted are those used for density calculation since 1981. Please see Appendix B, methods for a description of their derivation.

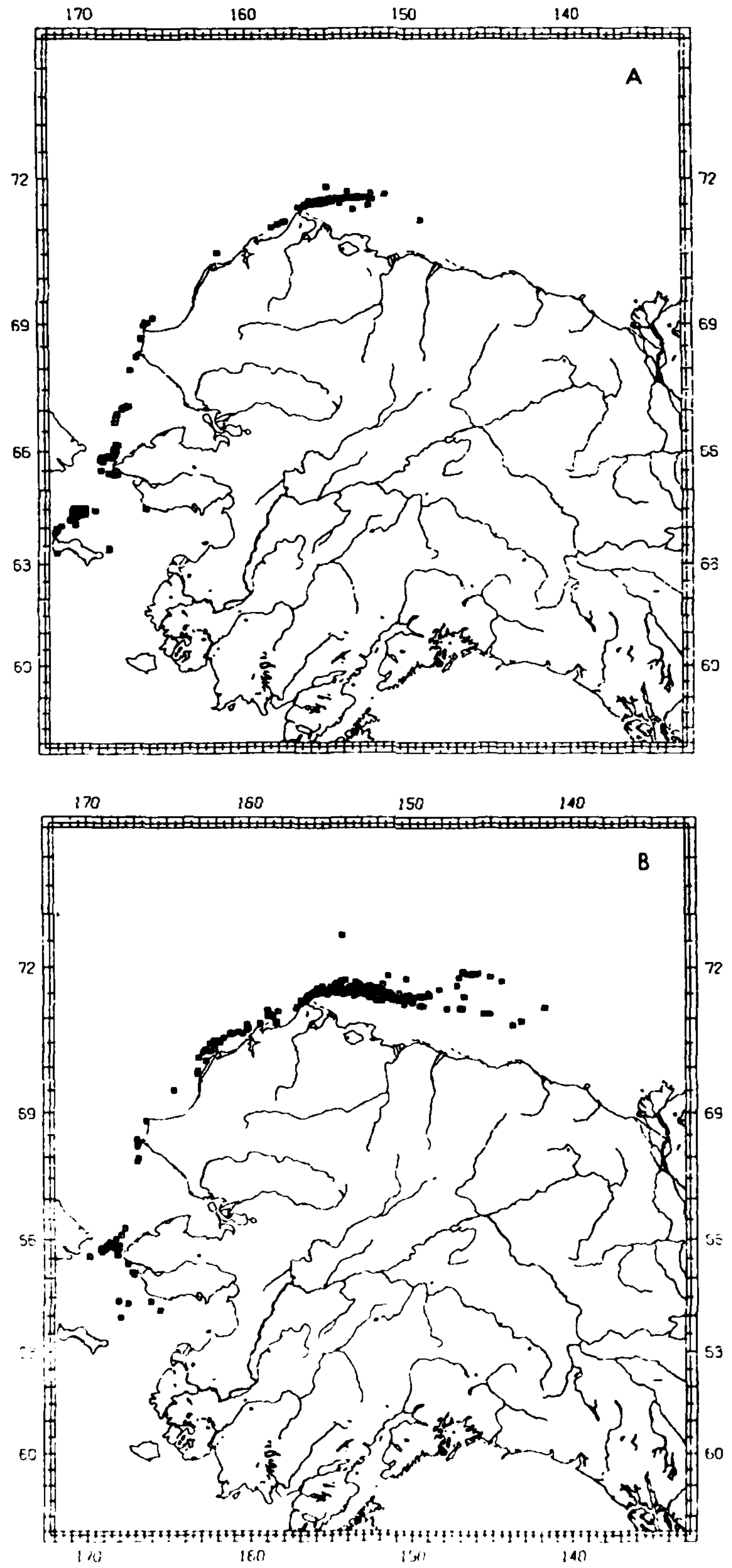

Figure 19. Distribution of 891 sightings representing 2605 bowheads plotted by month, spring 1979-1983.

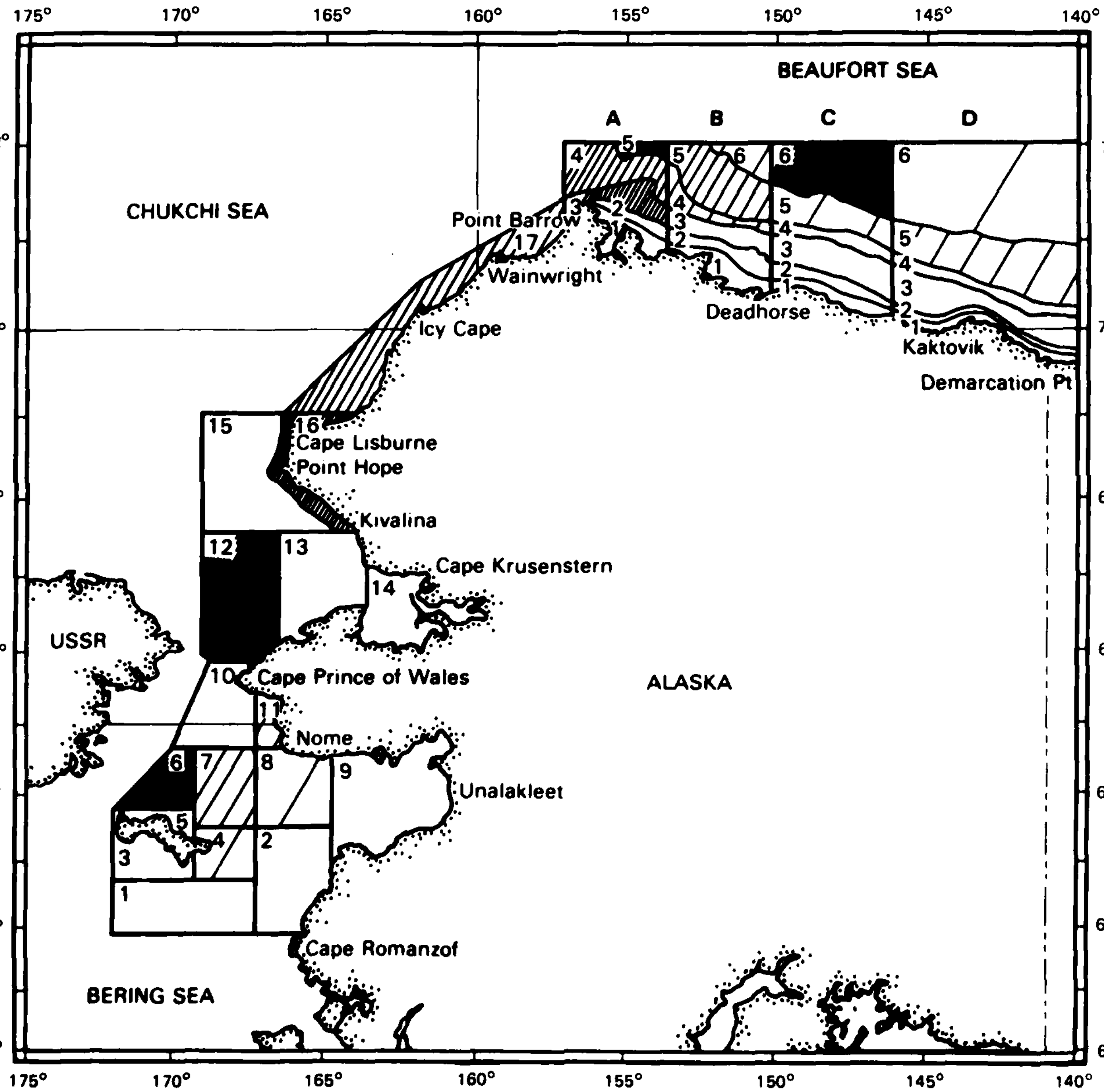

Figure 20. Highest observed bowhead densities/region, spring 1979–1983.

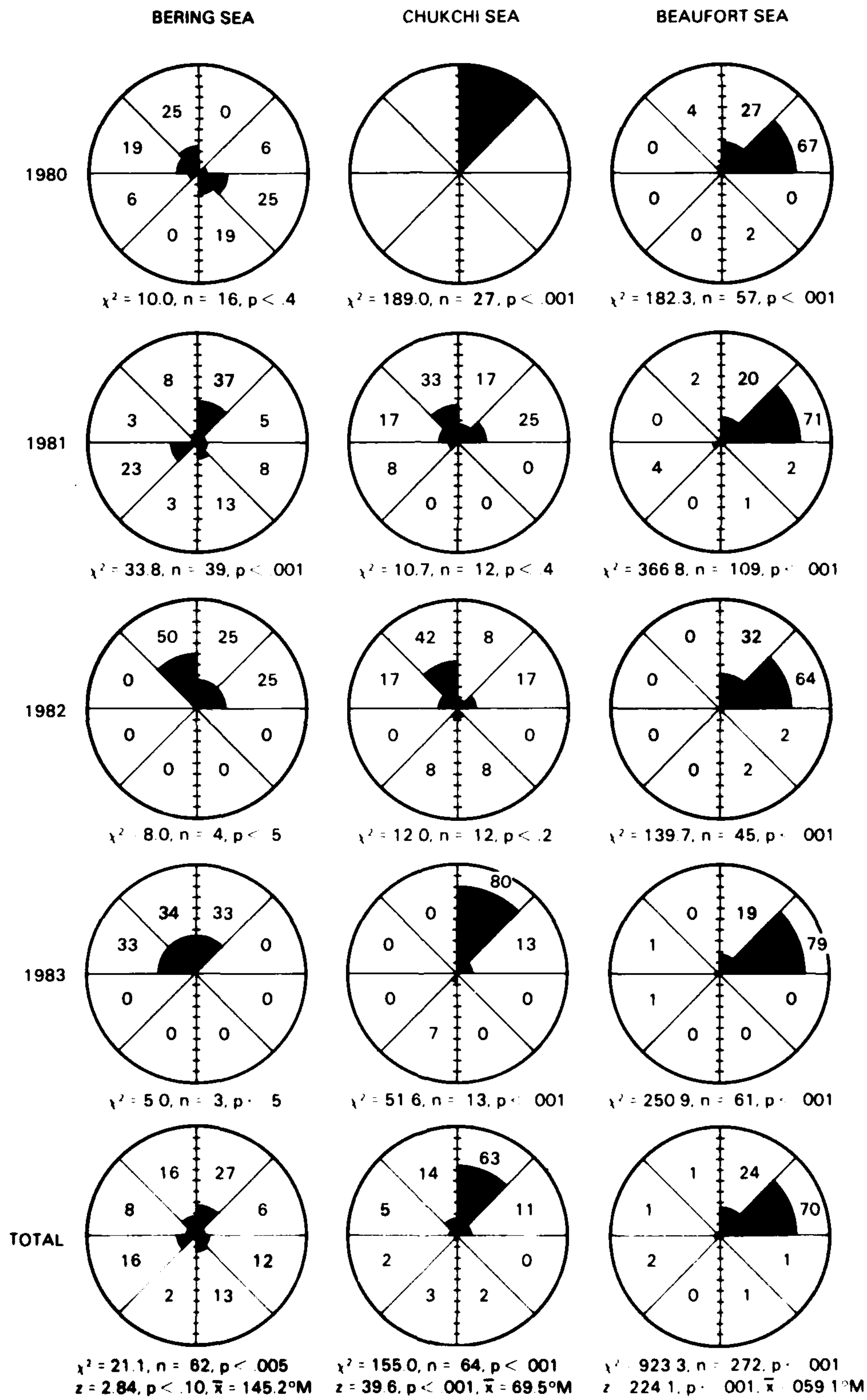

Figure 21. Directions of bowheads in the northern Bering, Chukchi and Beaufort Seas, spring 1980-1983. Numbers within the pie diagrams are percentages.

Chukchi Sea and appeared to delay at least some bowheads in the open water area north of Cape Prince of Wales through mid-May (Johnson et al, 1981). In 1981 through 1983 ice conditions were not as heavy and few bowheads were seen in the northern Bering southern Chukchi area after the third week of April. Large numbers of bowheads seen north of St. Lawrence Island on surveys conducted in early through mid-April 1981 however indicate that open water areas in the northern Bering southern Chukchi Sea area may be important aggregation points for bowheads as they commence their northward migration. No flights were made in this area in 1979.

The timing of the migration in the Beaufort Sea northeast and east of Point Barrow fluctuated somewhat over the five years. However, it generally retained a pulse-like character as described in Braham et al (1980) with two observed peaks in sighting per unit effort (SPUE; unit=1 hour flight time) interrupted by seven to nine day periods of relatively low SPUE (Table 22, Figure 22). Brueggeman (1982) hypothesized that the location of ice fronts in the southern and central Bering Sea may account for "spatial and temporal separation of whale congregations" seen along the migration route, and the observation of pulses at Point Hope and Point Barrow. Notably, the SPUE migration peaks in the heavy ice year of 1980 were approximately 20 days later than those observed in any other year; this is a second indication that ice conditions influence migration timing.

Table 22. Timing of pulses in bowhead spring migration past Point Barrow, as determined by SPUE/date, 1979 - 1983.

Year	First Pulse	Interval (days)	Second Pulse
1979	2 May	8	10 May
1980	22 May	7	29 May
1981	1 May	8	9 May
1982	4 May	9	13 May
1983	2 May	8	10 May

Behavior and Sound Production

Bowhead behavior observed each year along the migration route included swimming, diving, resting, milling, mating, and displaying (Table 23). Swimming and diving were referred to as migratory behaviors while all others, commonly seen when groups of whales were encountered, were classed as social behavior.

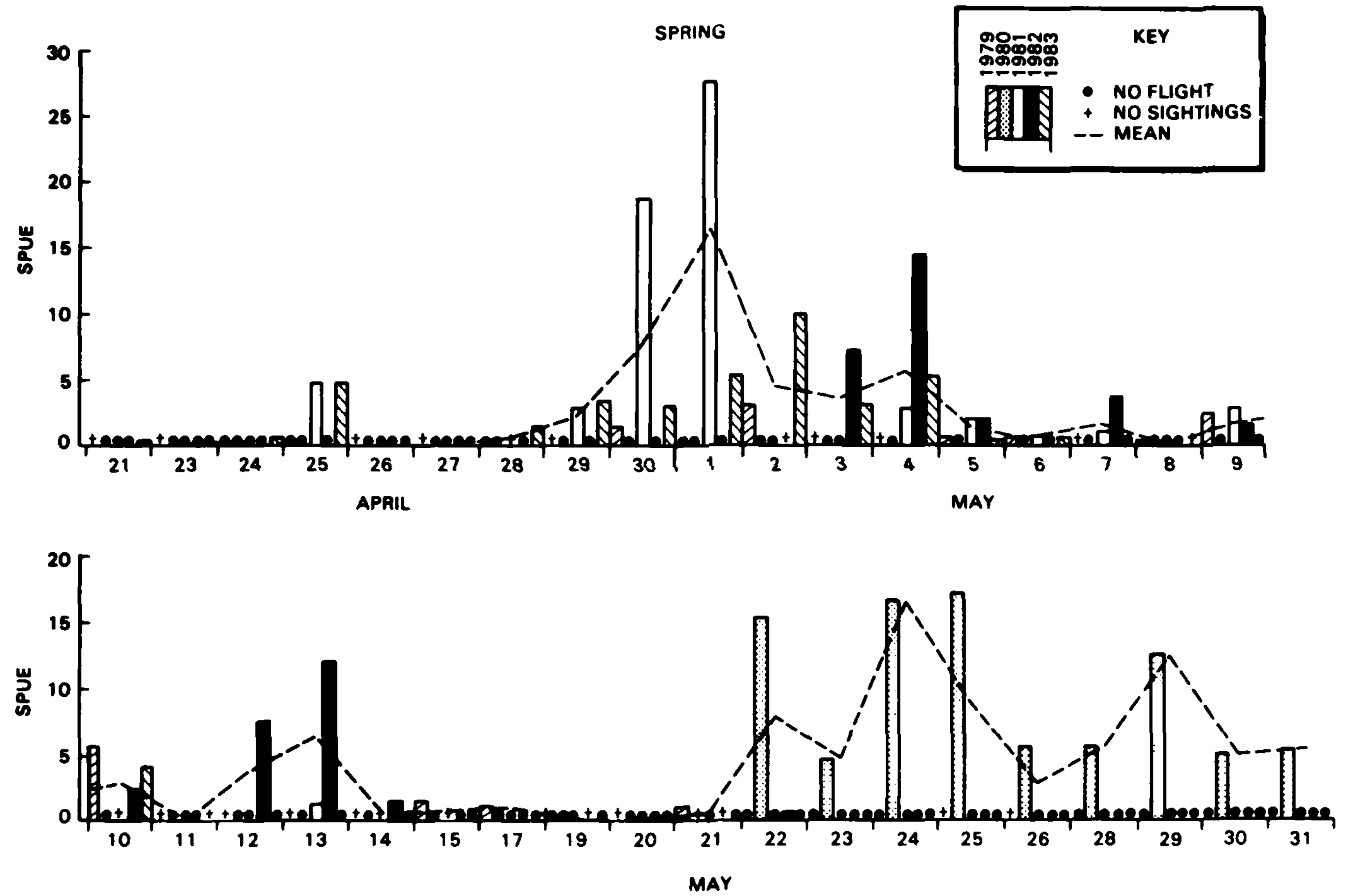

Figure 22. Bowhead sightings per unit effort (SPUE) by date. spring 1979–1983.

Table 23. Summary of bowhead behavior in the Bering, Chukchi and Beaufort Seas, spring 1979 - 1983.

SPRING			LOCATION			
	Behavior	Year	Bering Sea No.(%)	Chukchi Sea No.(%)	Beaufort Sea No.(%)	Total No.(%)
MIGRATORY	SWIM	1979	-	-	17(100)	17
		1980	0(0)	11(41)	54(44)	65
		1981	0(0)	18(56)	140(68)	158
		1982	3(100)	23(39)	139(70)	165
		1983	3(100)	19(90)	143(74)	165
		Total	6(3.9)	71(51.1)	493(66.9)	570(55.4)
	DIVE	1980	0(0)	16(59)	64(52)	80
		1981	2(4)	2(6)	38(19)	42
		1982	0(0)	13(22)	11(6)	24
		1983	0(0)	0(0)	18(9)	18
		Total	2(1.3)	31(22.3)	131(17.8)	164(16.0)
SOCIAL	REST	1980	77(83)	0(0)	5(4)	82
		1981	14(26)	12(38)	9(4)	35
		1982	0(0)	18(31)	16(8)	34
		Total	91(59.9)	30(21.6)	30(4.1)	151(14.7)
	MILL	1980	12(13)	0(0)	0(0)	12
		1982	0(0)	2(3)	21(11)	23
		Total	12(7.9)	2(1.4)	21(2.8)	35(3.4)
	MATE	1981	26(49)	0(0)	0(0)	26
		1982	0(0)	3(5)	9(5)	12
		1983	0(0)	2(10)	24(12)	26
		Total	26(17.1)	5(3.6)	33(4.5)	64(6.2)
	DISPLAY	1980	4(4)	0(0)	0(0)	4
		1981	11(21)	0(0)	18(9)	29
		1982	0(0)	0(0)	3(2)	3
		1983	0(0)	0(0)	8(4)	8
		Total	15(9.9)	0(0)	29(3.9)	44(4.3)
	GRAND TOTAL		152(100)	139(100)	737(100)	1028(100)

Not surprisingly, migratory behaviors comprised 71.4 percent of all behavior seen in spring. Resting was the most common social behavior (14.7 percent), with milling, mating, and displaying combined to account for 13.9 percent of all other social behaviors. Though occurrences of each behavior were seen in all seas, with the exception of displays in the Chukchi Sea, there were significant differences in the ratios of observed occurrence by sea ($\chi^2 = 451.1$, df = 16, $p. \leq 0.001$). Migratory behaviors were strongly associated with the Beaufort Sea, while all types of social behaviors were associated with the Bering Sea. Occurrence of behaviors in the Chukchi Sea were intermediate to these two extremes.

Average group size was nearly twice as large in the Bering Sea as in the Chukchi or Beaufort Seas ($t = 3.68$, $p. \leq 0.001$) (Table 24). This, combined with the higher observed occurrence of social behavior there, and the large aggregations seen north of St. Lawrence Island in early April 1981, indicate that socially active whales may coalesce in the northern Bering Sea prior to or in the early stages of the northward migration.

In general, larger groups of loosely directed resting or socially active whales were seen in the northern Bering Sea. In the Chukchi and Beaufort Seas the occurrence of active social behavior fell off as whales exhibited increasingly directed, migratory behavior. An overall review of bowhead directionality, behavior, and group size observed in spring may be summarized by sea as follows:

- In the northern Bering Sea, 60 percent of all whales seen were resting, 35 percent were involved in active social behavior, and 5 percent were migrating. Whales were seen alone or in groups of about six, and 57 percent of all whales maintained northerly headings.
- In the southern and coastal Chukchi Sea, 73 percent of all whales seen were migrating, 22 percent were resting, and 5 percent were involved in active social behavior. Whales were seen alone or in groups of about three, and 94 percent of all whales maintained northerly headings; 74 percent of these northeasterly headings.
- In the Beaufort Sea, 85 percent of all whales seen were migrating, 4.1 percent were resting, and 11 percent were involved in active social behavior. Whales were seen alone or in groups of about three, and 94 percent of all whales maintained northeasterly headings.

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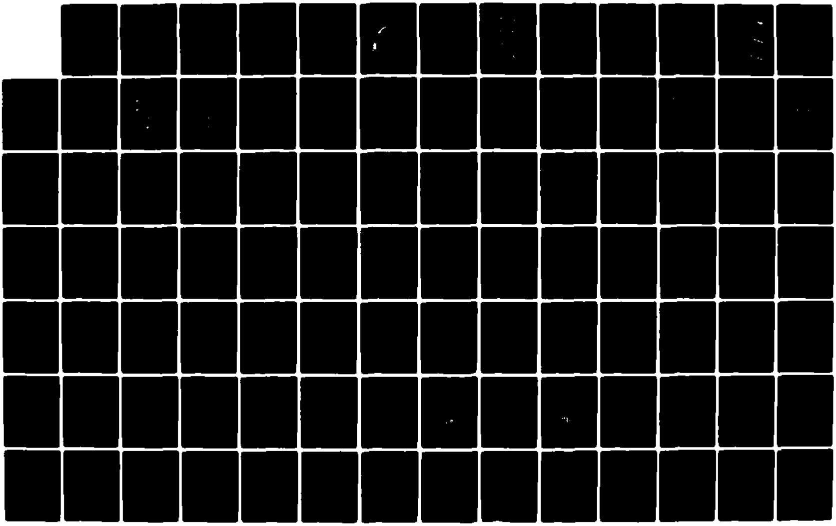

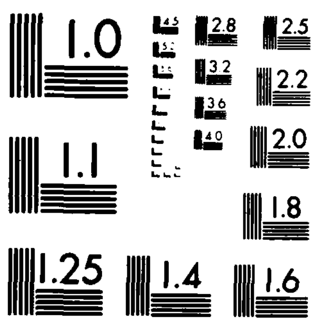
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Table 24. Bowhead average group size in the Bering, Chukchi and Beaufort Seas, spring 1979-1983.

Year	Bering Sea $\bar{x} \pm sd$ (n)	Chukchi Sea $\bar{x} \pm sd$ (n)	Beaufort Sea $\bar{x} \pm sd$ (n)	Total $\bar{x} \pm sd$ (n)
1979	-	-	4.15 ± 2.91 (13)	4.15 ± 2.91 (13)
1980	8.64 ± 14.96 (58)	2.33 ± 2.00 (15)	2.61 ± 0.91 (49)	5.44 ± 15.84 (122)
1981	7.95 ± 21.99 (116)	3.26 ± 1.82 (19)	1.82 ± 0.93 (62)	5.57 ± 3.47 (197)
1982	2.0 ± 0.0 (3)	2.43 ± 0.51 (14)	2.88 ± 1.49 (52)	2.74 ± 1.34 (69)
1983	2.0 (1)	6.0 ± 4.24 (2)	3.50 ± 2.19 (48)	3.57 ± 2.27 (51)
TOTAL	8.04 ± 7.87 (178)	2.86 ± 1.74 (50)	2.74 ± 3.92 (224)	4.84 ± 5.17 (452)

(n) = number of groups of two or more whales

Quantitative and qualitative description of sounds recorded near bowheads (Ljungblad et al (b)1982), and description of bowhead calls by others (Würsig et al. 1982) precedented aural (i.e., subject to listener's hearing) bowhead call analysis and tabularization for 1982 and 1983 data (see Table 8; Ljungblad et al, 1983). Sounds recorded in 1979-1981 have not been similarly analysed due to time constraints. The preliminary tabularizations indicate some differential call production, but as yet no statistically significant correlations have been found. Clark (1982, (a) 1983) has reported some success in identifying discrete southern right whale (Eubalaena australis) calls using multivariate statistical methods, and in correlating calls with observed surface behaviors. In Würsig et al (1982), these correlations were used in an attempt to infer biological significance of recorded bowhead calls. Such intraspecies comparisons, if done carefully, coupled with further quantitative analysis of recorded bowhead calls, may yield a more specific guide to these sounds and thereby enhance their value as a behavioral assessment tool. Clark ((b)1983) and Cummings et al (1983) have reported varied success in preliminary attempts to incorporate bioacoustic data to ice-based visual census efforts off Barrow in spring, indicating that acoustic data may enhance results of such studies.

Summer (July)

GRAY WHALE

The primary objectives of summer aerial surveys have been to determine the distribution, relative abundance, and behavior of gray whales in the northern Bering Sea and the southern and coastal Chukchi Sea. Surveys on which gray whales were seen in these areas have been conducted as early as 17 May and as late as 4 November, but July is the only month in which surveys were consistently flown since 1980, and therefore the only month across which comparisons were made in this review.

Distribution and Density

There were 664 sightings of 1536 gray whales made over four seasons (Figure 23). The plotted distribution generally reflects that reported in Moore and Ljungblad (1984) for data collected in 1980 and 1981. Gray whale distribution corresponds to areas where dense amphipod beds have been found. These are the north central Bering Sea and coastal St. Lawrence Island (Rice and Wolman, 1971; Zimushko and Ivashin, 1979; Nerini, 1984; Oliver et al, 1983), and to areas where such amphipod assemblages might occur, such as along the relatively narrow coastal Chukchi shelf. Although gray whale feeding grounds have been documented along the western coastal Bering and Chukchi Seas (Bogoslovskaya et al, 1981), none have been reported along the eastern coasts of these seas (Stoker, 1981).

Highest observed gray whale densities compiled over three seasons demonstrate that areas of greater abundance are those associated with feeding grounds, i.e., the north central Bering Sea and areas south-southeast of St. Lawrence Island (Figure 24). Notably, the coastal Chukchi Sea supported relatively high densities of grays in 1982. Between 1981 and 1983, 2 percent to 35 percent of all gray whales seen in July were found along the Chukchi coast, and of these, up to 38 percent were feeding (Table 25). Though in 1981 and 1982 a nearly identical percentage of grays were seen along the Chukchi coast, the observed density in 1982 was an order of magnitude higher than 1981.

The coastal Chukchi Sea does not appear to be an optimum feeding ground in all years, but when food is available* relatively high whale densities may be

*Note: Gray whales seen with mud plumes infer feeding and are the only evidence of prey availability in this case.

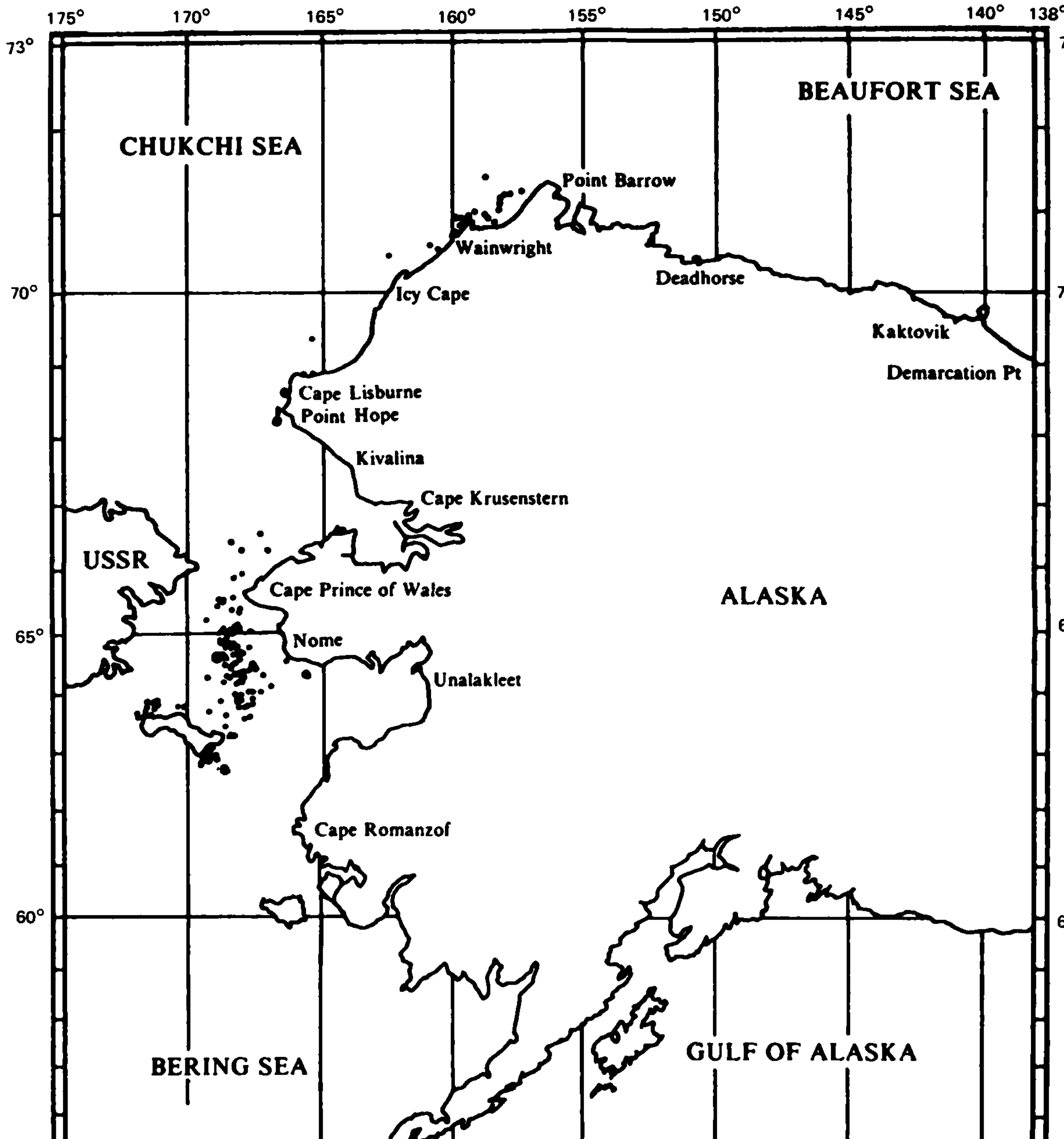

Figure 23. Distribution of 664 sightings of 1536 gray whales, summer 1980–1983.

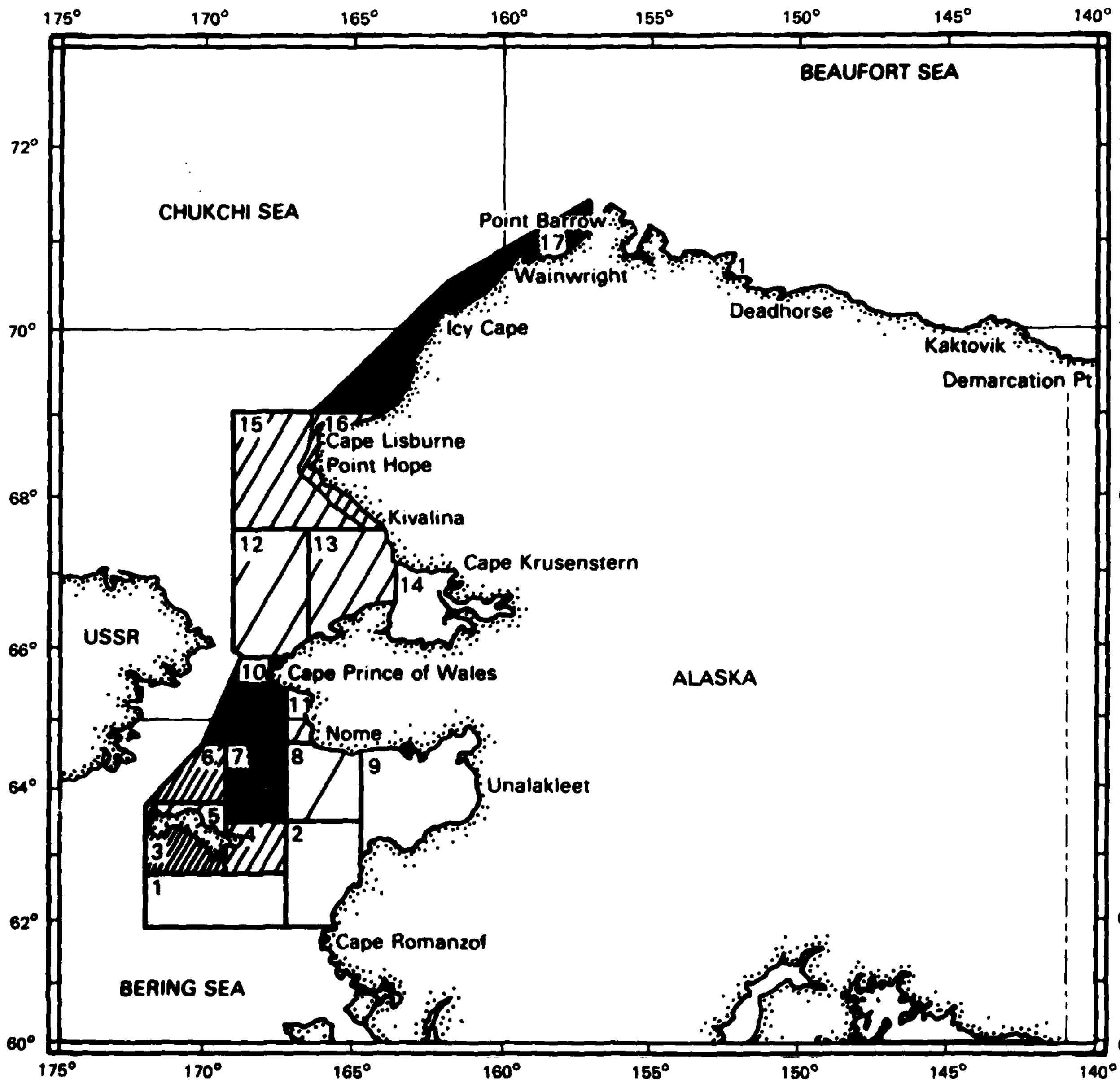

Figure 24. Highest observed gray whale densities/region, summer 1980–1983.

Table 25. Observed gray whale density, and incidence of feeding observed along the eastern Chukchi Sea coast in July 1981-1983.

Year	Density/nmi^2	% Feeding
1981	0.03-0.040	0
1982	0.21-0.43	38
1983	0.0-0.11	7

observed there. Lesser variation in gray whale distribution and density have been found in the northern Bering Sea where peak densities and associated distribution has shifted only slightly to the northwest from 1981 to 1983. In 1981, the center of the gray whale distribution cluster in the northern Bering Sea was approximately 63°55'N, 167°30'W. In 1982 the center of this cluster was 64°25'N, 167°30'W and in 1983 the central point was approximately 64°45'N, 168°45'W. These variations in gray whale distribution and density are presumed to reflect shifts in the abundance and location of food concentrations as 48 percent to 63 percent of whales seen in these areas of concentration were observed feeding.

Behavior and Sound Production

Grays were seen from 5 m to 140 km from shore in water from 4 m to 40 m deep. Whales very near shore sometimes appeared to be resting on the bottom. Grays not feeding were usually swimming or resting. Headings in the Bering and Chukchi Seas showed no significant clustering (Figure 25). There was no consistent predominant heading across years, nor between seas within the same year, except 1982 when the 225°-270° M octant was dominant in both seas. This occurrence is unexplained.

The most surprising gray whale behavior noted was that of apparent geographical segregation of a cow-calf group in 1982. That year eighteen calves were among the 111 grays distributed between Cape Lisburne and Wainwright, while only one calf was seen in a total of 209 whales between St. Lawrence Island and 50 km southwest of Point Hope (about 68°N). There was roughly 150 km separation between the first sighting of the 111 gray whales seen on 31 July and the most northerly gray whale sighting prior to that date in 1982. Segregation of cow-calf and/or female groups in gray whales in northern latitudes has not been documented as a common occurrence as, for example, it has in sperm whales, Physeter macrocephalus (Best, 1979). Such segregation in gray whales may be an

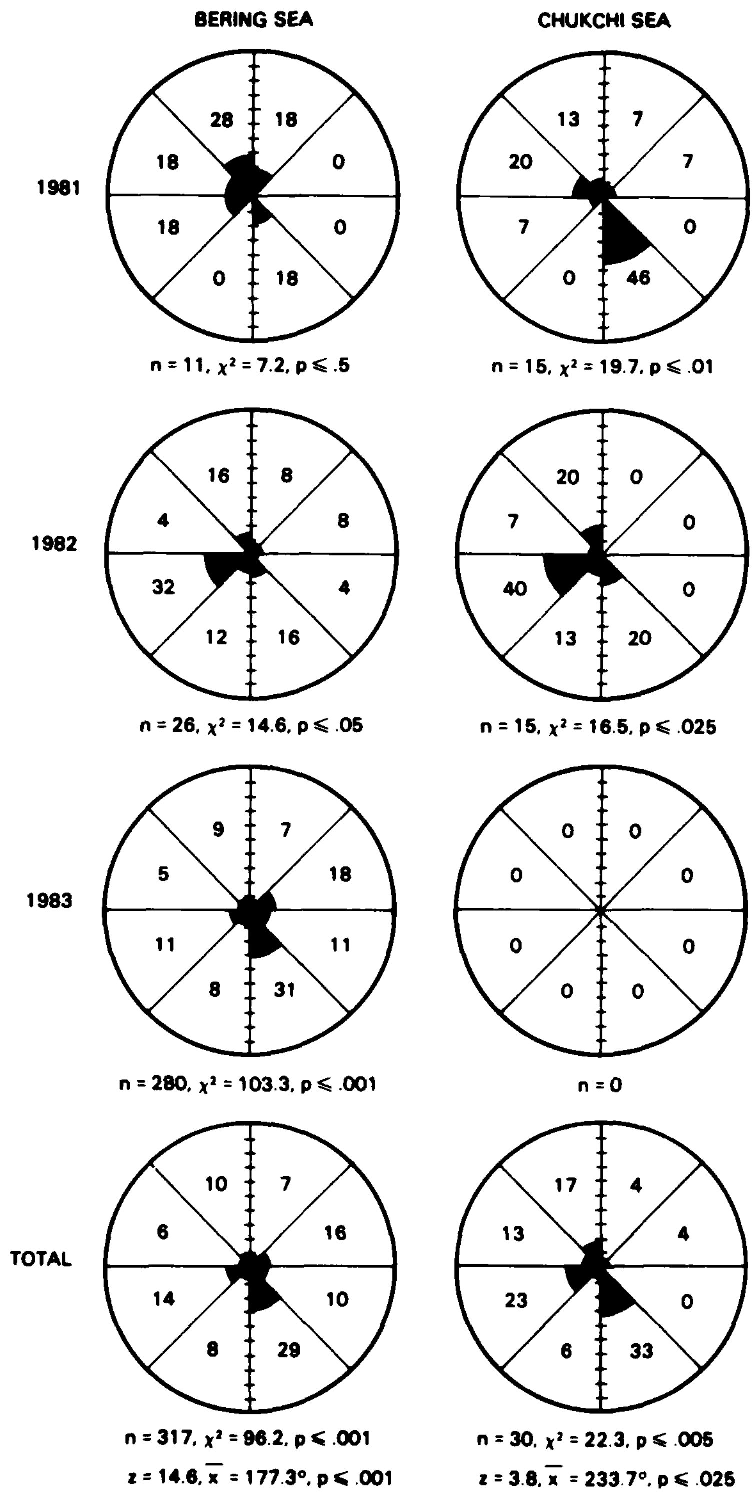

Figure 25. Direction of gray whales in the northern Bering and Chukchi Seas, summer 1981-1983. Numbers within the pie diagrams are percentages.

extension of a segregation found in migrating grays. "The migration is in fact a procession of gray whales segregated according to age and sex. Females with calves apparently travel (in spring) farther offshore than the rest of the herd." (Sumich, 1976, p. 233-34). If this segregation trend continues, it would not be surprising to find large numbers of cows with calves, and possibly other adult females, together on the feeding grounds. Additionally, only one calf was seen among a total of 1026 gray whales in 1983, a ratio that seems disproportionately low and possibly resultant of segregation (i.e., unseen cow-calf group(s).

Sounds recorded near feeding gray whales in the northern Bering Sea and Norton Sound were analysed and categorized into three types (Moore and Ljungblad, 1984). The most prevalent sounds were amplitude modulated (AM) signals termed N_1-type that to the ear sounded like metallic knocks. These sounds were most often emitted in series with approximately 12 knocks/series at a repetition rate of about seven knocks/second. N_1 - type sounds showed great variation in repetition rate, series duration, and frequency at maximum amplitude. Other sounds recorded near grays were moan-like (N_3), or belch-like (N_4). Both sound types showed amplitude and frequency modulation (FM), were roughly in the 100 to 750 Hz frequency band and were about 0.25 to 1.5 s long. A sound that may have been associated with an underwater blow (N_6 -type) was recorded in 1983. A concise review of gray whale sound production and further explanation of the sound category scheme adopted here may be found in Dahlheim et al (1984).

Fall (August-October)

BOWHEAD WHALE

The primary objectives of the fall aerial surveys have been to determine the distribution and timing of the bowhead migration, to derive relative and/or absolute abundance estimates in or near proposed or existing federal lease areas and to record and describe bowhead behavior and sound production in association with these goals.

Distribution and Density

There were 660 sightings of 1121 bowheads made over the five fall seasons (Figure 26). The distribution, plotted by month, shows that in August bowheads were generally found in the northeast Alaskan Beaufort Sea between 143° and 140° W, north of 70°30'N. In September, bowheads were found across the Beaufort Sea, generally along the continental shelf break and into the northern coastal Chukchi Sea. The same distribution was found in October, with more whales seen in the Chukchi Sea. This distribution generally corresponds to monthly bowhead catch data of the late 19th and early 20th centuries, summarized in Sergeant and Hoek (1974).

Highest observed bowhead densities compiled over five seasons and calculated by month depict westward shifting abundance indices in the Beaufort Sea from August through October (Figure 27). Highest density observed in August was in region D-5. In September highest density was calculated for region C-3 and in October, region B-3. A relatively high bowhead density was also calculated for the coastal Chukchi Sea for September and October from data gathered in 1982-1983.

Bowhead distribution and density in fall may be directed in part by prey availability. Bowheads feed primarily on pelagic arthropods including euphausiids, amphipods, copepods, mysids and pteropods (Lowry et al, 1978) and have been classified as bottom-skimming feeders (Nemoto, 1976). Würsig et al (1982) suggest bowheads feed from surface waters and through the water column, as well as near or at the bottom, to take in sufficient food.

Stomachs of five bowheads taken near Barter Island between 20 September and 11 October 1979 were found to contain primarily copepods and euphausiids (Lowry and Burns, 1980). Though the great majority of prey items found were pelagic species, the presence of pebbles and some bottom dwelling species

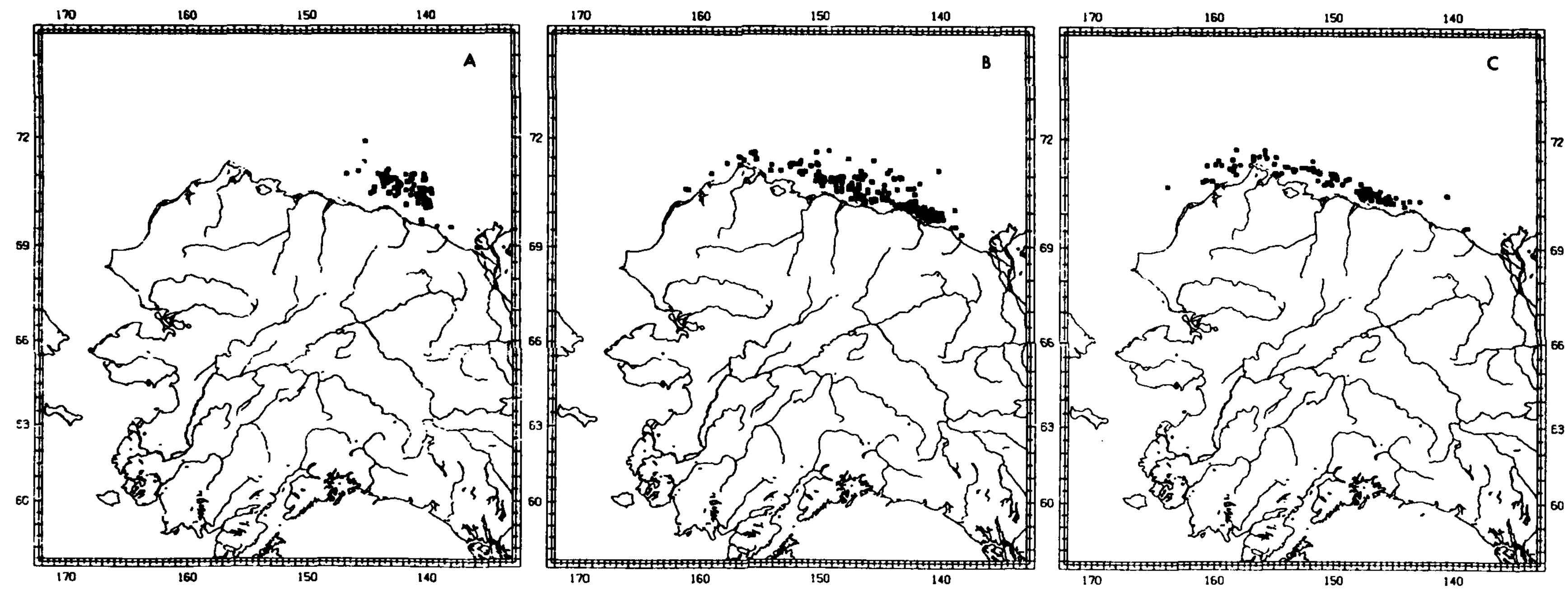

Figure 26. Distribution of 660 sightings representing 1121 bowheads plotted by month, fall 1979-1983.

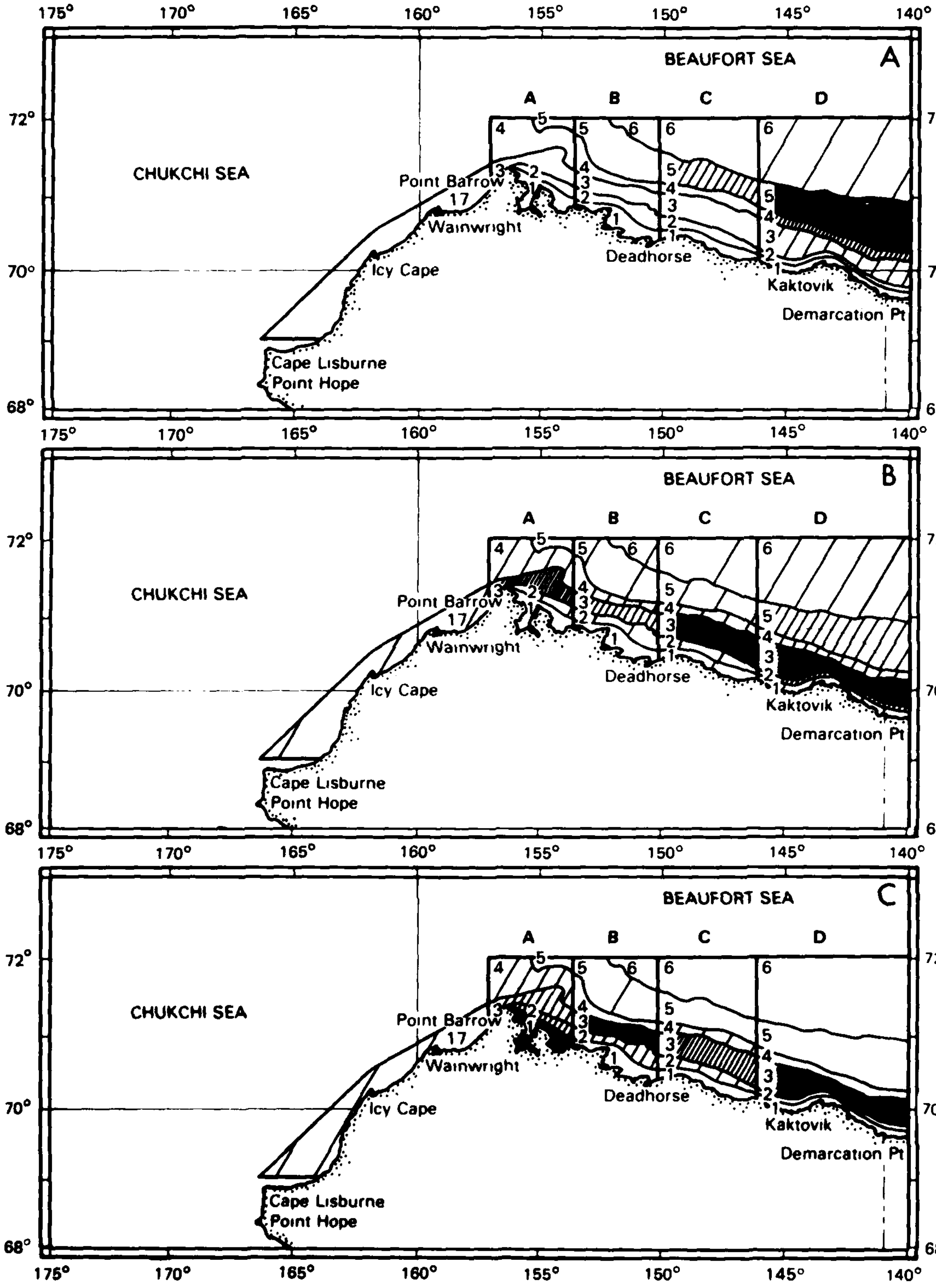

Figure 27. Highest observed bowhead densities/region calculated by month, fall 1979–1983.

indicated that the whales taken near Barter Island did some feeding near the sea floor. An extensive benthic faunal assemblage has been reported on the shelf and continental slope of the southwestern Beaufort Sea between Prudhoe Bay and Barter Island (Carey et al, 1974). Megaepifauna collected with a 3.7 m semiballon shrimp trawl equipped with a 1.3 cm stretch mesh inner liner exhibited a range of distributional patterns. Some species were concentrated within narrow depth zones along the middle and outer continental shelf, while others were found only below the shelf break. Notably, megaepifauna assemblages with the strongest internal structure (affinity index > 75 percent) occurred on the mid-shelf in depths roughly between 27 and 50 m. Average faunal assemblage stability decreased with increasing depth.

The highest density and biomass of zooplankton in the Beaufort Sea occur in the Arctic surface (0-200 m) water (Hopkins, 1969). Grainger (1965) described species typical of inshore and the upper 100 m of offshore waters as those most tolerant of temperature and salinity variations, and included in the group the copepod Calanus hyperboreus, a species found in all five bowhead stomachs examined by Lowry and Burns (1980). Griffiths and Buchanan (1982) reported copepod biomass near the surface where bowheads were observed feeding to be an order of magnitude greater than in areas where whales were not observed in the Canadian Beaufort. Overall, highest biomasses were found below the thermocline (≥10 m) often just above the bottom.

Bowheads have been seen apparently feeding from August to mid October in water 11 m to 62 m deep, i.e., depths reported to have stable megaepibenthos assemblages and highest zooplankton densities. A plot of suspected bowhead feeding areas representing 19 dates and 26 locations is similar to that of overall bowhead distribution seen during the fall migration (Figure 28). Although additional observations of possible feeding behaviors were made over the years 1979-1983, these selected data represent groups of whales that remained in the same general area for > 15 minutes and exhibited at least three of the following conditions indicative of feeding:

- Echelon swimming formations
- Mud or silt streaming from the mouth (head)
- Clear swaths of water appearing behind whales swimming through otherwise murky waters
- Non-directionality

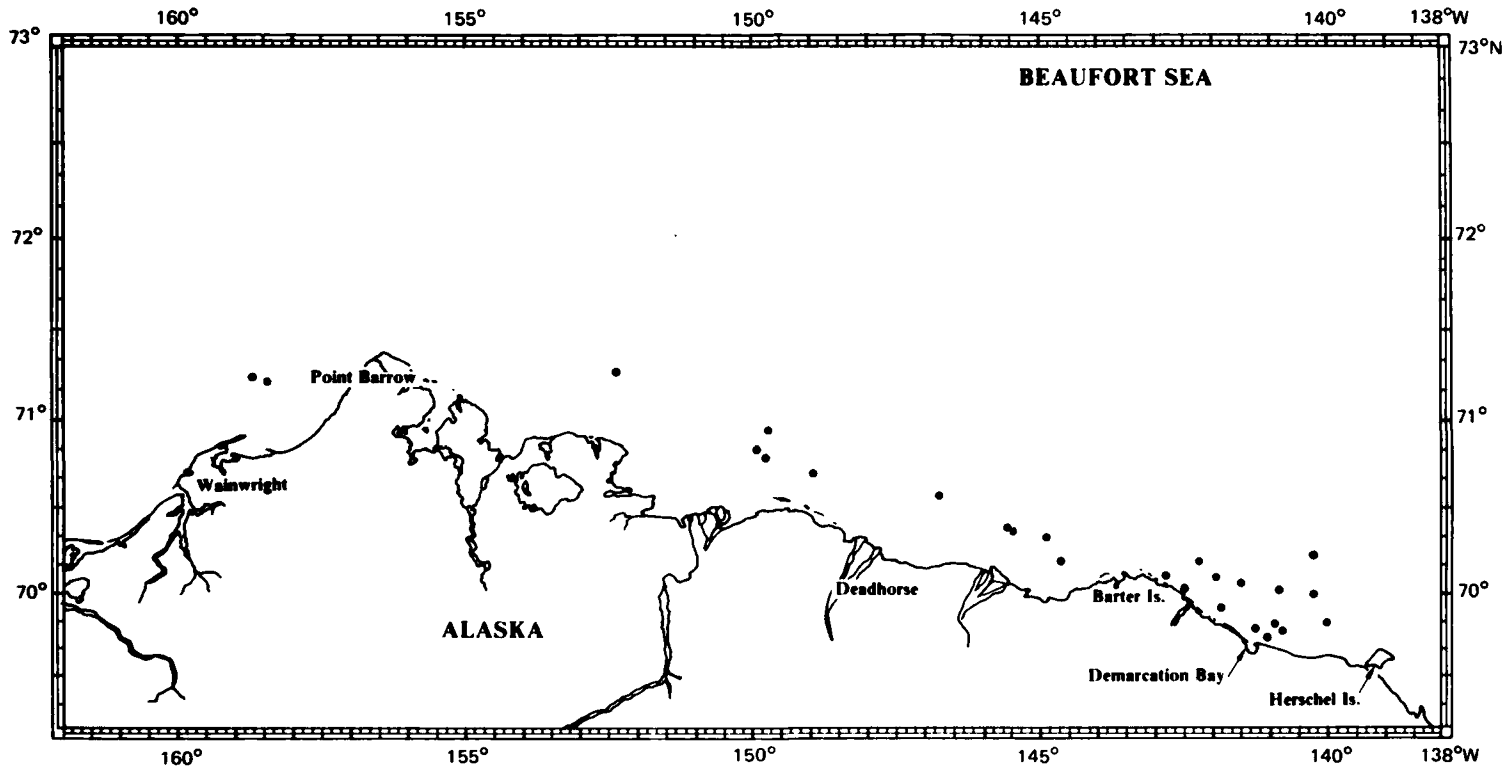

Figure 28. Suspected bowhead feeding areas, fall 1979–1983. Each point designates whale/whales exhibiting feeding behavior.

- Defecation
- Synchronous group diving and surfacing
- Milling; slow overall movements
- Open-mouth, surface swimming

Additionally, bowhead groups (numbering 100) that appeared to be feeding have been seen by others "near" Smith Bay in September 1974 (Ray and Wartzok, 1980) and between Point Barrow and Smith Bay in September 1976 (Braham et al, 1980).

Bowheads that appeared to be feeding were seen most often in September, generally in the latter half of the month (Table 26). Notably, feeding was observed much less often in years (1980, 1983) when heavy ice coverage in the Beaufort Sea persisted throughout the fall, than years (1979, 1981, 1982) when waters were nearly ice free.

Table 26. Sightings of bowheads that appeared to be feeding per hour of survey effort by two week interval, fall 1979-1983.

Year	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-20 Oct	Total
1979	-	0	0	4.69	0	1.04
1980	-	-	0.50	0	0	0.04
1981	-	0	0.94	1.33	0.54	0.85
1982	0	0	0.61	2.34	0	0.64
1983	0.09	0	0	0	0.14	0.05
Total	0.05	0	0.35	1.15	0.12	0.40

With the exception of whales seen in early August, the observed bowhead distribution and relative abundance conforms to areas where food availability is reported or thought to be relatively high, i.e., shallow shelf and surface waters $\leq$ 200 m. Though the number of sightings of whales that appeared to be feeding was relatively low (see Table 30), increased apparent feeding behavior was seen each year as the major component of bowheads entered the Beaufort Sea in September.

Migration Timing and Habitat Relationships

In fall, bowheads migrate through ice conditions that may range from approximately 8-9/10 to open water. Headings of whales in the Beaufort Sea during the fall migration were primarily westerly (Figure 29). Significant

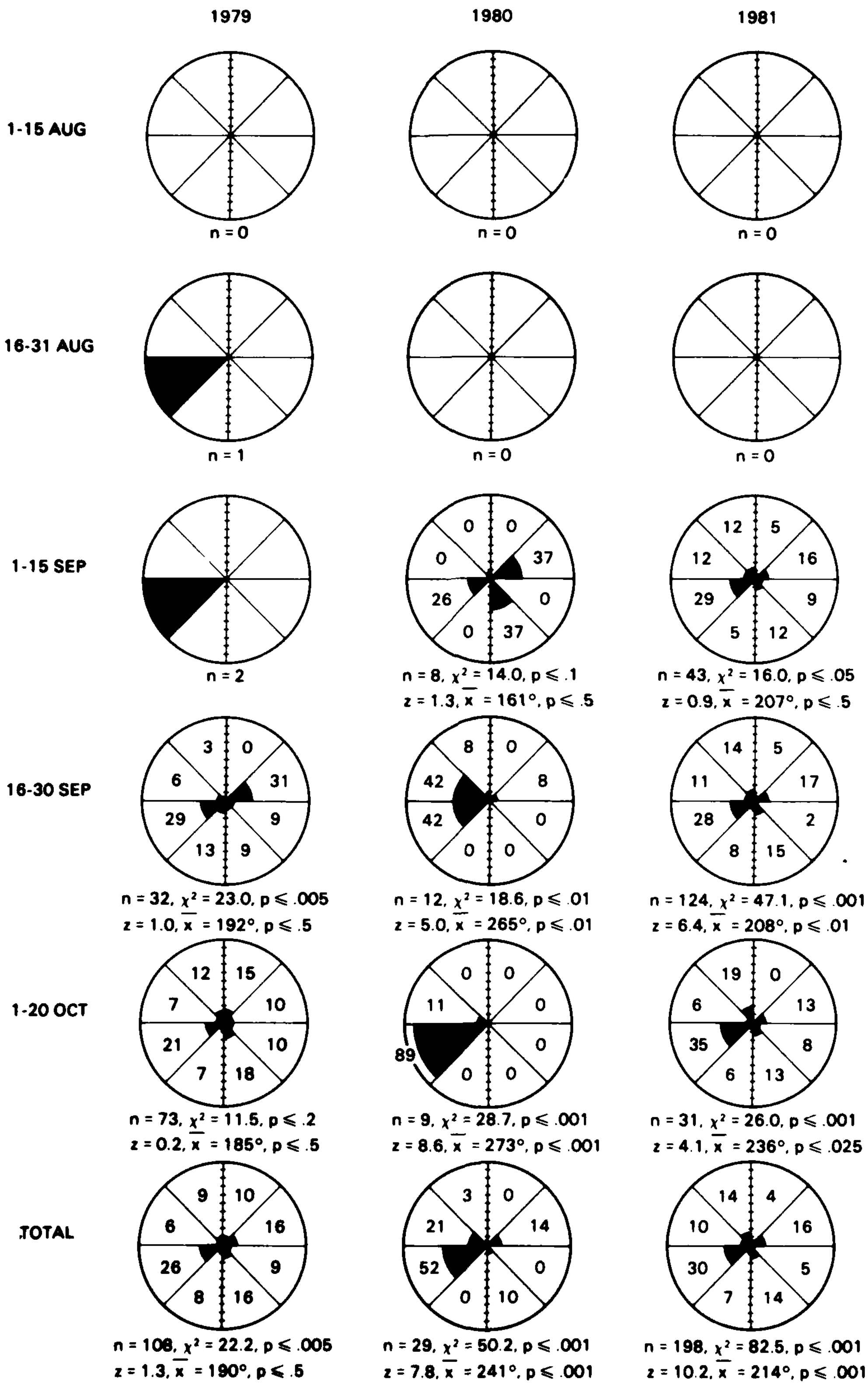

Figure 29. Direction of bowheads in the Beaufort and Chukchi Seas, fall 1979–1983. The numbers within the pie diagrams are percentages.

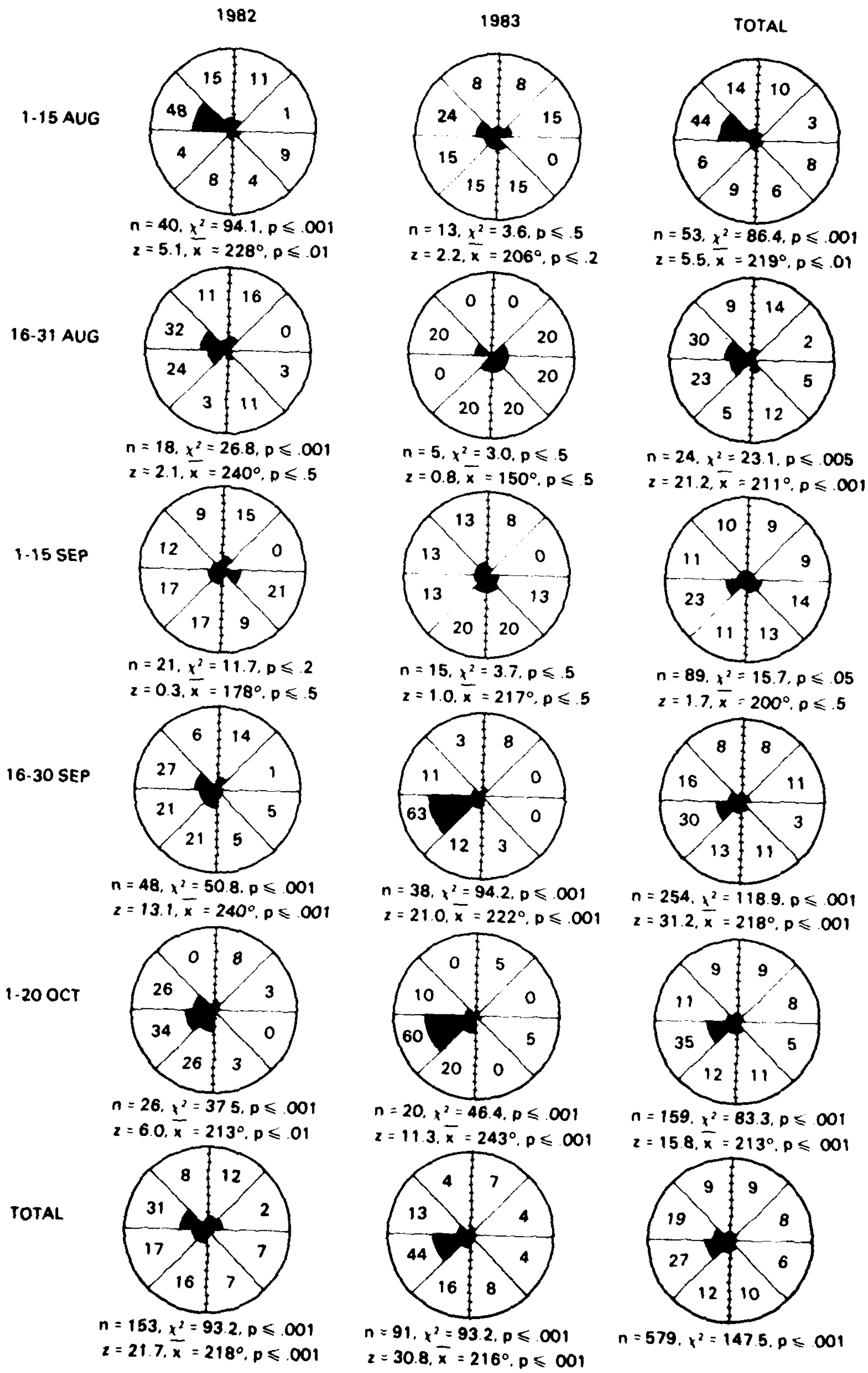

Figure 29. (Cont)

clustering around mean headings was noted in all years only in late September and October. Headings of whales seen in August and early September near the Canadian border north of 71°30'N varied over the years.

The timing and character of the bowhead migration across the Beaufort Sea and into the Chukchi Sea in September and October appears related to extent of ice coverage and its effect on food availability (Table 27). Ice coverage limits primary, and therefore secondary, productivity in the Beaufort Sea by deflecting and diffusing incident light. Schell et al (1982, p. 81) stated that "the retreat of the pack ice northward in summer, nutrients supplied by terrestrial run off, and the maximum euphotic depths lead to the maximum productivities observed" in the Beaufort Sea. Throughout the fall of 1980 and 1983, ice coverage remained heavy in the Beaufort Sea, while in 1979, 1981, and 1982 waters were relatively ice free through September and into early October. The differences between years when possible feeding was an often observed behavior and the years when the observed feeding behaviors were rare can be generally correlated to relative ice coverage. In the light ice years, 50 sightings, comprising 273 whales that seemed to be feeding, were noted as the migration moved slowly to the west (Ljungblad et al, 1983). In the heavy ice years, four sightings, representing 16 whales, exhibited suspected feeding behavior. The three possible feeding observations noted in 1983 were made by the bowhead-seismic survey crews (Ljungblad et al, 1984, in preparation). The first observation was near Barter Island on 26 September. No whales were seen during an extensive search of this area and surrounding waters the following day. Likewise an area northwest of Barter Island and near Flaxman Island had possible feeding whales on 29 September. Again subsequent searches of these areas and areas to the west did not relocate any whales. The fact that no feeding whales were relocated in 1983 may indicate the possible effects of heavy ice cover or prey abundance. Generally in 1979, 1981, and 1982, once feeding whales were found in an area, whales were observed for several days in the same general area as they moved slowly west.

The average migration period was approximately 10 days longer during light ice years, with SPUE peaks occurring approximately eight days later than in heavy ice years (Table 27). Average SPUE in heavy ice years was 1.56, while for light ice years it was 15.56. During the heavy ice years, few groups or aggregations of bowheads were seen as indicated by all SPUE peaks ≤ 5 (Figure 30). In contrast,

Table 27. Summary of bowhead migration timing, character and habitat relationships in the Alaskan Beaufort Sea, fall 1979-1983.

						General Ice Habitat	
Year	1979	1980	1981	1982	1983	LIGHT	HEAVY
Average September Ice Coverage	0/10 - 1/10	6/10 - 9/10	0/10 - 1/10	0/10	6/10 - 9/10	0/10 - 1/10	6/10 - 9/10
Feeding Bowheads* (No. Sightings/ No. Whales)	14/75	1/3	18/74	18/124	3/13	50/273	4/16
Migration: Period	20 Aug - 20 Oct	4 Sep - 9 Oct	7 Sep - 20 Oct	2 Sep - 17 Oct	3 Sep - 17 Oct	31 Aug - 19 Oct	3 Sep - 13 Oct
Length (Days)	(61)	(35)	(43)	(45)	(44)	(49.7)	(39.5)
SPUE: Peak	7.33	1.25	15.75	23.60	1.86	15.56	1.56
Date	14 Oct	18 Sep	28 Sep	16 Sep	24 Sep	29 Sep	21 Sep

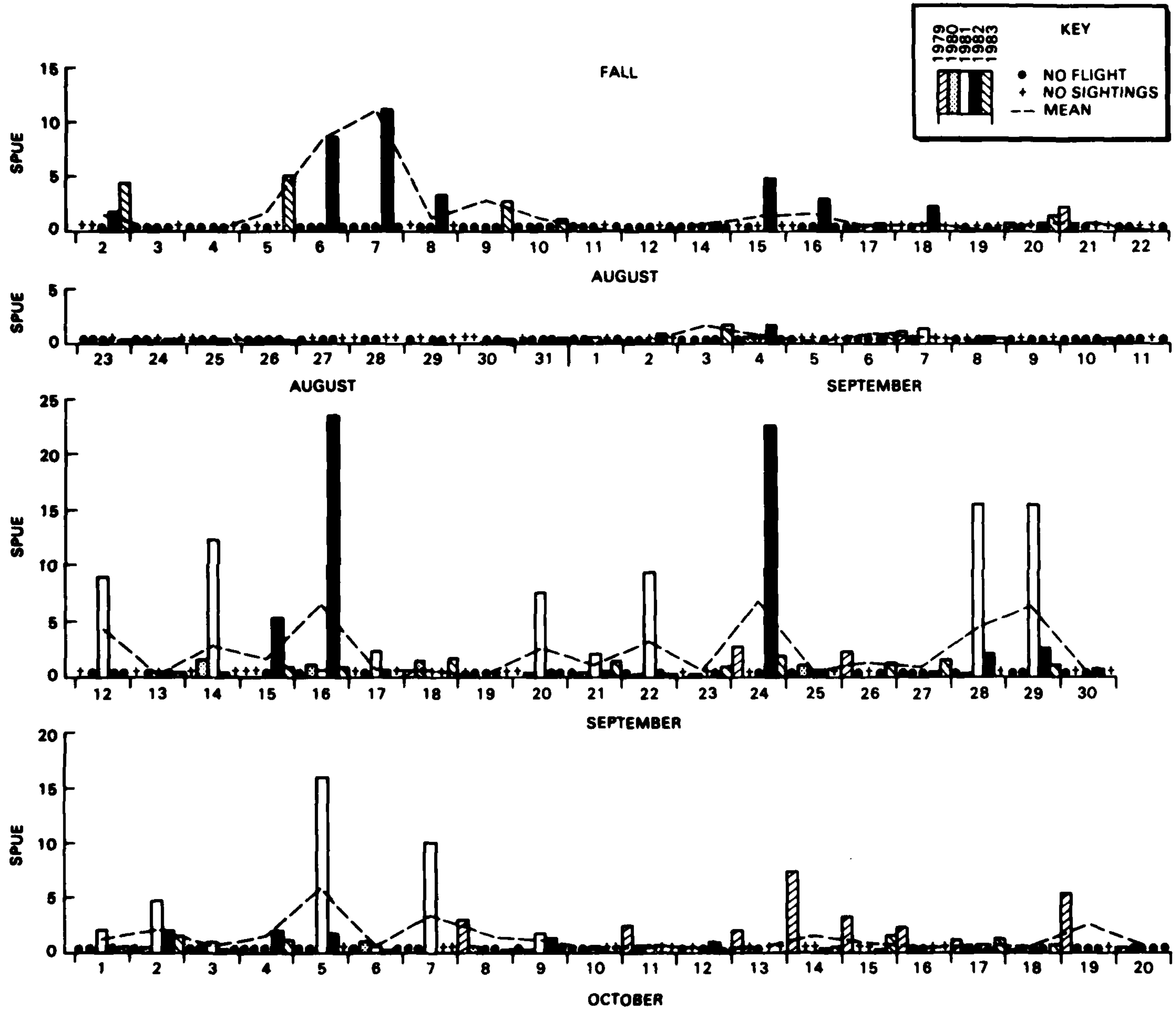

Figure 30. Bowhead sightings per unit effort (SPUE) by date, fall 1979–1983.

five to eight SPUE peaks ≥ 5 were noted in the light ice years of 1981 and 1982. Surveys in 1979 were concentrated very near shore and thus affect SPUE comparisons for that year. The larger and greater number of SPUE peaks during light ice years correlate strongly with the higher incidence of observed bowhead feeding in those years ($\chi^2 = 68.2$, df = 8, $p \leq 0.0001$).

The bowhead aggregations found offshore resulting in early August SPUE peaks in 1982 and 1983 may also be related to feeding. Schell et al (1982) reported primary production peaks occur in June offshore and in August, near shore in the Alaskan Beaufort Sea. Theoretically, bowheads may encounter a bloom of secondary producers offshore in July and August. In 1982 and 1983, bowheads were found primarily offshore in deep (> 2000 m) water in August and early September, and in transitional (50-2000 m) or shallow depths (< 50 m) in later September and October (Table 28). In 1979-1981 little or no effort was dedicated to offshore surveys, which limits available comparisons. If whales migrating past Point Barrow in late May and early June encounter an offshore food source in the eastern Alaskan Beaufort Sea, they may swim no further east than approximately 140° W. When offshore food sources are reduced in availability in August and early September, they may be the first whales to move west and initiate the fall westerly migration, or to shallower coastal waters. In short, late arrivals to the Beaufort Sea in spring may be the first westward migrants in fall.

In light ice years, as whales migrate west from summer feeding grounds they aggregate and appear to feed in areas where dense prey is likely. In years when heavy ice limits productivity, bowheads may remain on Canadian feeding grounds longer. Then, upon moving west and finding insufficient prey abundance in the Alaskan Beaufort Sea, they simply may continue swimming west. A multiple regression of date, longitude at bowhead sighting, depth and ice cover for 1983 data found the strongest correlation to be date and longitude ($r^2 = 0.758$), indicating a strong westward progression with time. Correlation between depth and longitude ($r^2 = 0.351$) and depth and date ($r^2 = 0.197$) indicated whales were seen in shallower water as they moved west with time. The number/percent of bowheads seen in shallow, transitional, and deep depth regimes supports this trend (Table 28). There was some disparity in the proportion of bowheads found in each depth zone in 1982 and 1983 ($\chi^2 = 33.4$, df = 4, $p. \leq .001$) that may reflect the difference between the years in ice coverage. In 1982, a relatively light ice year, most sightings were in shallow water, and the majority of whales were sighted in

Table 28. Number/percent of bowheads sightings in deep (over 2000 m), transitional (50 m - 2000 m) and shallow (less than 50 m) water, fall 1979 - 1983.

	1-15 Aug No.(%)	16-31 Aug No.(%)	1-15 Sep No.(%)	16-30 Sep No.(%)	1-20 Oct No.(%)	TOTAL No.(%)
1979						
Deep	-	0(0)	0(0)	0(0)	0(0)	0(0)
Transition	-	1(25)	2(100)	1(4)	0(0)	4(3)
Shallow	-	3(75)	0(0)	26(96)	108(100)	137(97)
Total	-	4(100)	2(100)	27(100)	108(100)	141(100)
1980						
Deep	-	-	0(0)	0(0)	0(0)	0(0)
Transition	-	-	0(0)	0(0)	0(0)	0(0)
Shallow	-	-	9(100)	15(100)	9(100)	33(100)
Total	-	-	9(100)	15(100)	9(100)	33(100)
1981						
Deep	-	0(0)	0(0)	0(0)	0(0)	0(0)
Transition	-	0(0)	0(0)	0(0)	1(2)	1(1)
Shallow	-	1(100)	26(100)	80(100)	40(98)	147(99)
Total	-	1(100)	26(100)	80(100)	41(100)	148(100)
1982						
Deep	2(3)	2(9)	0(0)	0(0)	0(0)	4(2)
Transition	49(86)	19(86)	6(24)	11(12)	4(14)	89(40)
Shallow	6(14)	1(5)	19(76)	78(88)	25(86)	129(58)
Total	57(100)	22(100)	25(100)	89(100)	29(100)	222(100)
1983						
Deep	1(4)	4(57)	4(21)	0(0)	0(0)	9(8)
Transition	24(96)	3(43)	15(79)	21(51)	8(33)	71(61)
Shallow	0(0)	0(0)	0(0)	20(49)	16(67)	36(31)
Total	25(100)	7(100)	19(100)	41(100)	24(100)	116(100)
DEPTH						
Deep	3(4)	6(18)	4(5)	0(0)	0(0)	13(2)
Transition	73(89)	23(68)	23(28)	33(13)	13(6)	165(25)
Shallow	6(7)	5(14)	54(67)	219(87)	198(94)	482(73)
TOTAL	**82(100)**	**34(100)**	**81(100)**	**252(100)**	**211(100)**	**660(100)**

- = no surveys flown

shallow water as early as the beginning of September. In 1983, a heavier ice year, most sightings were in transitional depths. It was October before a majority of whales were sighted in shallow water. Perhaps in 1983 food was available in sufficient quantities to feed only in the transitional depths where ice coverage was somewhat lighter. This either promoted a deeper euphotic zone, or food was not available anywhere in the Alaskan Beaufort Sea in quantities to allow efficient feeding, and thus bowheads were strictly in a migrational mode. It is doubtful that they were precluded from the shallow depths by the existence of the ice coverage as it was neither thick nor solid.

There were 37 bowheads seen in the Chukchi Sea during September-October, 1982-1983 from 0.5 to 40 km from shore (Figure 31). These whales exhibited mostly southwest headings ($\chi^2 = 33.1$, $p. \leq 0.001$) with clustering about a mean heading of 221.5° M ($z = 14.1$, $n = 26$, $p. \leq 0.001$). Fall bowhead sightings in the Chukchi Sea can be encompassed by a rectangle bounded by latitudes 71°45' N to 70°44' N and longitudes 156°58' W to 164°00' W. If an average southwesterly heading of 222° M is applied to that rectangle, a hypothetical picture develops of bowheads dispersing across the Chukchi Sea and crossing roughly over Herald Shoal (70°30' N, 171°30' W). This pattern of a possible southwestward dispersion of bowheads across the Chukchi Sea in fall complements, yet diverges from the currently held model, the suggestion that bowheads primarily follow the ice front west to Herald and Wrangel Islands before following the Chukotka peninsula south and through the Bering Strait (Braham et al, 1980).

Ray and Wartzok (1980) reported five bowheads slightly west Herald Shoal on 11 October 1975. Johnson et al (1981) reported 104 bowheads sighted along the Siberian coast between Tenkergin and Cape Onman (68° N-69° N, 174° W-178° W) between 16 and 18 October 1979; only three bowheads were observed northeast of Wrangel Island. Bogoslovskaya et al (1981) reported 274 bowheads along the mainland coastline between early September and mid October, with only four to 12 whales seen off Herald Island in October 1980. Marquette et al (1981) reported 227 bowheads sighted along this strip of the Siberian coast between 21 and 23 September 1980, with no bowheads seen near Wrangel or Herald Island. Miller et al (1983) concluded that bowheads seen along the Siberian coast in September and October 1979 to 1982 were early returnees from the western arctic stock, and not whales that had spent the summer in the Chukchi Sea. Our data, in conjunction with these published accounts, support the hypothesis of a dispersion of at least some bowheads south and west across the Chukchi Sea after

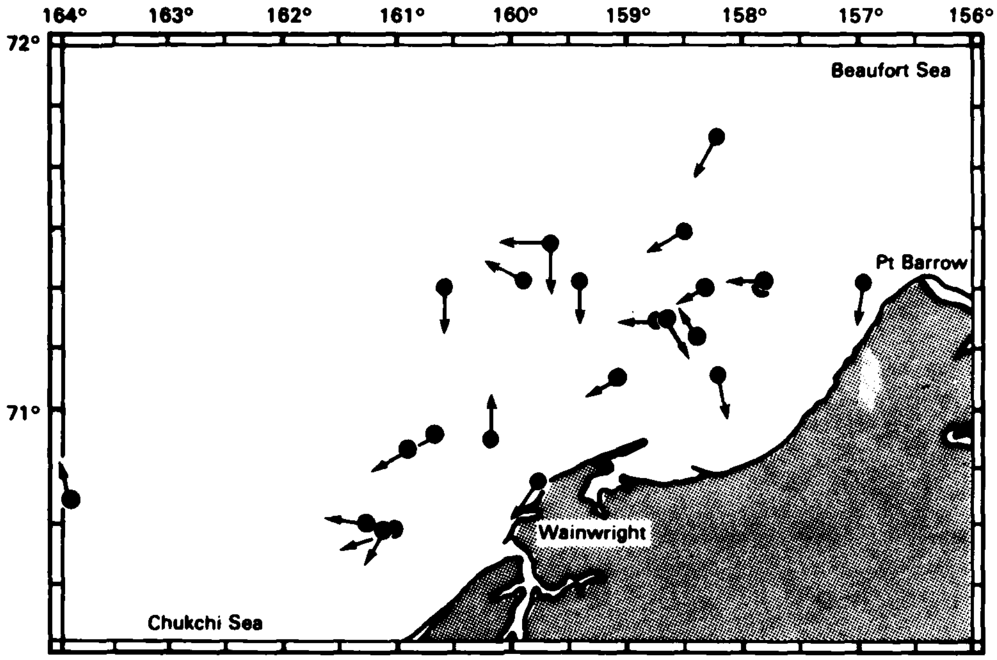

Figure 31. Bowhead sightings in the Chukchi Sea, fall 1982-1983.

they round Point Barrow late in the fall. Migration patterns in the Chukchi Sea may be more dispersed, compared with those seen in the the Beaufort Sea, due to the differences in the bathymetry and ice. That is, the Chukchi Sea lacks the shelf break, and usually the ice coverage pertinent to discussion of the bowhead migration across the Beaufort Sea.

The timing of observed bowhead distribution in the Beaufort and Chukchi Seas during the fall migration can be depicted by a continous distribution of bowheads in a general trapezoid shape moving west across the Beaufort Sea and dispersing southwest across the Chukchi Sea from August through October (Figure 32).

The following observations support this hypothesis:

- The direction of the bowheads remained westerly (see Figure 29) from August through October, with significant clustering in late September and October.
- In August 1982-1983, bowheads were seen further offshore to the west and closer to shore to the east.
- The strongest correlate with bowhead sighting longitude was date ($r^2 = 0.758$).

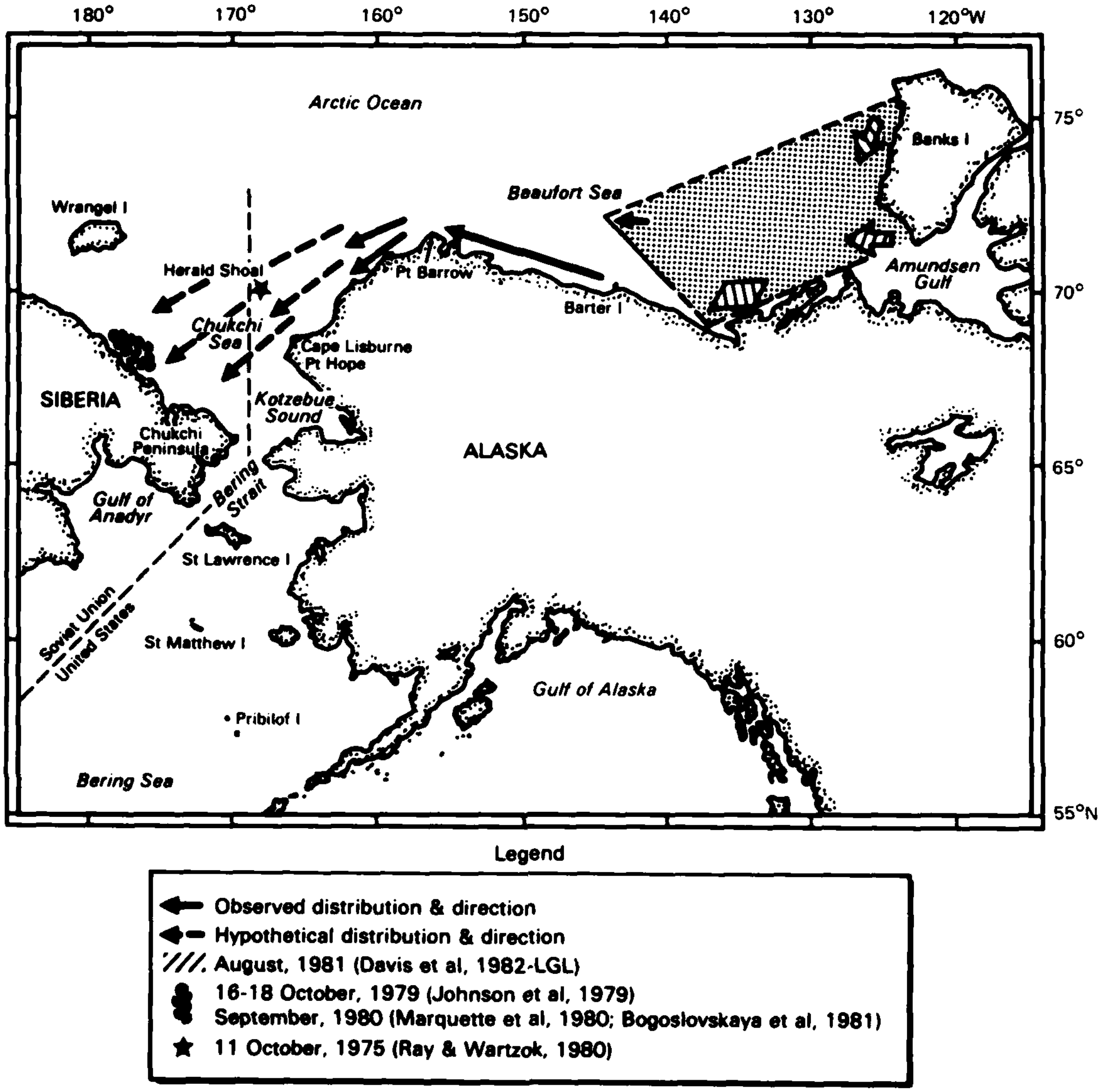

Figure 32. General representation of likely fall bowhead migration showing approximate distribution in August, September and October, 1979–1983.

- Correlation between longitude and depth, and depth and date indicated whales were seen in shallower water as they moved west with time.
- In 1983 ice coverage was not significantly correlated with longitude ($r^2 = 0.060$) nor with depth at sighting ($r^2 = 0.067$), indicating ice is not necessarily a major factor in determining whale location in fall.
- Bowheads seen in the Chukchi Sea in September and October were 0.5 km to 40 km from shore and clustered about a mean heading of 222°M.

In this model, the bowheads seen offshore in early August are the leading edge of a much larger westerly moving population and suggest that major migratory movements could occur that early in the Alaskan Beaufort Sea. By the first part of September, whales are seen near Demarcation Bay and Barter Island as the population shifts to the west and onshore in east. Continued westward movement brings the majority of the population through the Alaskan Beaufort Sea along the shelf break where continued feeding may be optimized in September and early October. In late September and early October, bowheads disperse across the Chukchi to the Siberian coast.

Calf Sightings and Estimated Recruitment

Calves were seen with migrating bowheads from August through October (Table 29). In 1979 and 1980 calves were seen only in October. In 1981, calves were seen in September and October, and in 1982 and 1983, when a greater flight effort was directed offshore, calves were seen from August through October.

Table 29. Sightings and estimated Gross Annual Recruitment Rate (GARR)* of bowhead calves by two-week interval, fall 1979-1983.

Year	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-20 Oct	Total
1979	0	0	0	0	6 (3.9)	6 (2.5)
1980	0	0	0	0	1 (8.3)	1 (2.2)
1981	-	0	1 (3.2)	1 (1.1)	1 (2.0)	3 (1.7)
1982	5 (4.6)	6 (16.2)	4 (7.4)	7 (2.8)	1 (2.2)	23 (4.7)
1983	2 (4.1)	1 (10.0)	3 (12.5)	3 (5.6)	4 (11.4)	13 (7.6)
Total	7 (4.6)	7 (13.0)	8 (6.5)	11 (2.2)	13 (4.4)	46 (4.1)

*GARR = Number Calves/Total Number Bowheads

Estimates of gross annual recruitment rate (GARR) ranged from 1.7 percent in 1981 to 7.6 percent in 1983. Highest GARR was seen between mid August and early September (X^2=5.29, $p \leq .10$). Estimates of bowhead GARR have usually been low relative to other mysticetes. Estimates derived from studies since 1976 over a variety of seasons, geographical areas and survey platforms range from 0.0 to 12.4 percent as summarized in Nerini et al (1983).

Although within each year there is one or several peak calf sighting date(s), when the ratio of calves/total number of bowheads seen per one hour of survey

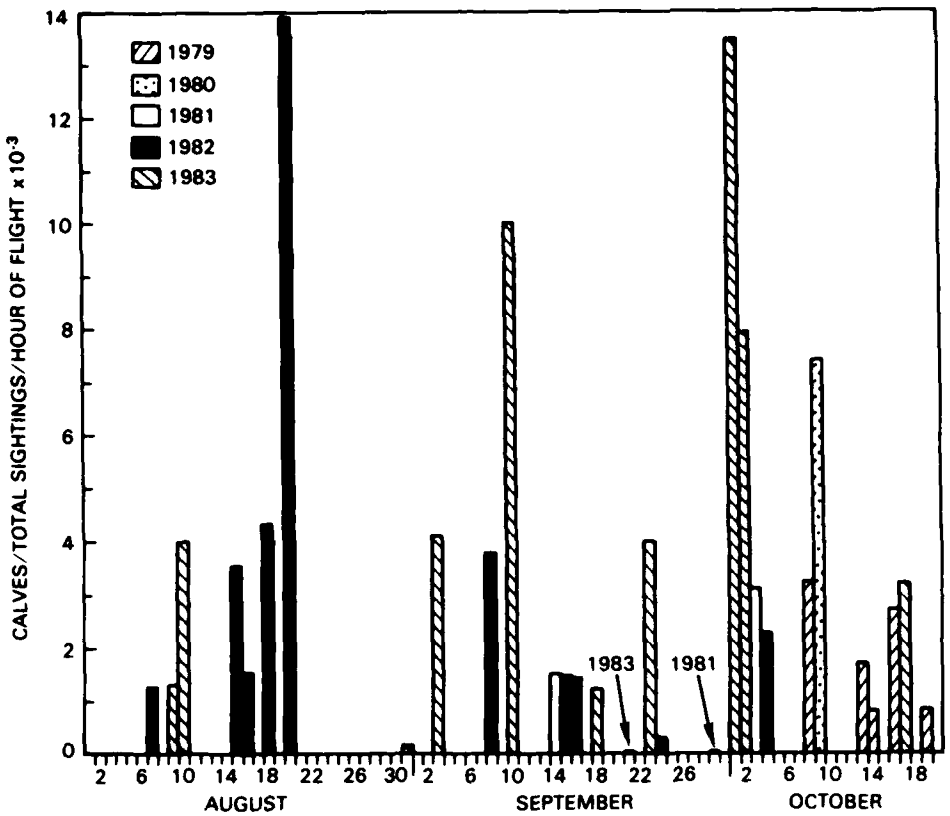

Figure 33. Ratio of bowhead calves/total number of bowheads seen by survey hour, fall 1979–1983.

effort is plotted, there is no cumulative peak period for all years (Figure 33). The periods of peak calf sightings in 1982 and 1983 may be generally correlated to peak sightings of whales offshore and near shore. Calf sighting peaks in mid-August were associated with those whales seen offshore near the Canadian border, while the peaks seen in September and early October were associated with whales seen near shore.

Evidence of segregation of bowhead age-classes in the eastern Beaufort Sea has been demonstrated via photogrammatic length frequency studies (Cubbage et al, 1984; David et al, 1983). Differences in age-class were found between locations each year, and age-class location seemed to vary between years. The GARR provided here was not corrected for such segregation. Chapman (1983) noted that to derive an accurate GARR, given the existence of segregation, all components of the population must be sampled and then combined weighed by the number of whales comprising each component. Because survey effort is directed

toward the Alaskan Beaufort Sea, the component(s) of the population sampled is not known with certainty for any year. Thus, the derived GARR (Table 29) and the GARR/survey hour (Figure 33) represent only the portion of the bowhead population in the Alaskan Beaufort Sea during the stated time period.

Behavior and Sound Production

The predominant behavior of bowheads throughout the fall was active migration (55.3 percent) (Table 30); 12.4 percent of all whales seen were resting, 15.8 percent were feeding, 8.1 percent were milling, 4.2 percent exhibited cow-calf behavior and 4.2 percent were displaying. The highest proportion of feeding whales was seen in mid to late September. Observation of cow-calf interactions coincided with peak sighting periods of mid to late August and early October. Displays and resting behaviors were seen across all time periods.

The average group size, excluding solitary whales, was 2.86 ± 1.55 ($n=249$) (Table 31). There was no difference in group size among the time intervals ($t=0.81$, $p \leq 0.50$) except between late September when large groups of socializing or feeding whales were seen and October ($t=3.43$, $p \leq 0.001$) when smaller, more migrational groups were encountered.

The only significant difference in group size was between 1982, a light ice coverage year with a relatively high mean group size, and the heavy ice coverage years 1980 ($t=3.44$, $p \leq 0.001$) and 1983 ($t=3.60$, $p \leq 0.001$). It seemed that more whales were actively migrating and not aggregated in groups in heavier ice years and, therefore, were harder to sight.

Sounds recorded near bowheads in fall 1982 and 1983 have been aurally analysed as described for spring samples (see Table 19; Ljungblad et al, 1983). As for spring samples, this initial analysis has indicated some differential call production when data from different recording circumstances are compared, although significant correlation with observed whales surface behaviors has not been found. Some intriguing results of aural analysis has been the identification of several call sequences and notation of several unusual, rarely recorded calls. A complete analyses of all bowhead sounds recorded between 1979 and 1983 might yield a classification scheme that would enhance the utility of bioacoustic data as a behavior monitoring and population assessment tool.

Table 30. Bimonthly summary of bowhead behavior, fall 1979 - 1983. No.(%) = Number (percent).

Behavior	Year	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-20 Oct	Total*
SWIM	1979	-	4	4	8	73	89
	1980	-	-	0	4	2	6
	1981	-	2	0	20	17	39
	1982	67	6	21	95	29	218
	1983	27	8	10	39	17	101
Total	No.(%)	94(59.9)	20(37.7)	35(29.7)	166(36.6)	138(61.9)	453(45)
DIVE	1979	-	0	0	1	2	3
	1980	-	-	0	17	8	25
	1981	-	0	0	10	5	15
	1982	5	5	11	24	3	48
	1983	2	0	4	5	1	12
Total	No.(%)	7(4.5)	5(9.4)	15(12.7)	57(12.6)	19(8.5)	103(10.3)
REST	1979	-	0	0	0	2	2
	1981	-	0	16	30	10	56
	1982	20	7	1	13	9	50
	1983	8	0	5	1	2	16
Total	No.(%)	28(17.8)	7(13.2)	22(18.6)	44(9.7)	23(10.3)	124(12.4)
FEED	1979	-	0	0	32	0	32
	1980	-	-	5	0	0	5
	1981	-	0	15	32	15	62
	1982	0	0	0	49	0	49
	1983	4	0	0	0	7	11
Total	No.(%)	4(2.5)	0(0)	20(16.9)	113(24.9)	22(9.9)	159(15.8)
MILL	1982	12	12	7	50	0	81
Total	No.(%)	12(7.7)	12(22.7)	7(5.9)	50(11.0)	0(0)	81(8.1)
COW-CALF	1979	-	0	0	0	6	6
	1980	-	-	0	0	2	2
	1981	-	0	0	2	2	4
	1982	4	5	7	0	2	18
	1983	0	2	2	2	6	12
Total	No.(%)	4(2.5)	7(13.2)	9(7.6)	4(0.9)	18(8.1)	42(4.2)
DISPLAY	1982	0	2	7	12	1	22
	1983	8	0	3	7	2	20
Total	No.(%)	8(5.1)	2(3.8)	10(8.5)	19(4.2)	3(1.3)	42(4.2)
GRAND TOTAL		157(100)	53(100)	118(100)	453(100)	223(100)	1004(100)

*behaviors not recorded for all whales
- = *no flight*

Table 31. Bimonthly summary of bowhead average group size, fall 1979 - 1983.

	1-15 Aug $\bar{x} \pm$ sd (n)	15-31 Aug $\bar{x} \pm$ sd (n)	1-15 Sep $\bar{x} \pm$ sd (n)	16-30 Sep $\bar{x} \pm$ sd (n)	1-20 Oct $\bar{x} \pm$ sd (n)	TOTAL $\bar{x} \pm$ sd (n)
1979	-	2.5±0.71 (2)	-	3.7±2.36 (20)	2.5±1.02 (24)	3.0±1.81 (46)
1980	-	-	2.5±0.71 (2)	2.75±0.96 (4)	2.0±0.0 (3)	2.44±0.73 (9)
1981	-	-	3.7±2.6 (20)	2.42±0.72 (24)	3.0±1.47 (14)	3.0±.81 (58)
1982	3.13±2.05 (24)	2.89±2.32 (9)	3.07±1.73 (14)	4.67±3.08 (43)	2.45±0.69 (11)	3.68±2.57 (101)
1983	3.67±1.0 (9)	2.50±0.71 (2)	2.25±0.50 (4)	2.3±0.67 (10)	2.1±0.32 (10)	2.6±0.91 (35)
Total	3.27±1.82 (33)	2.77±1.92 (13)	3.28±2.14 (40)	3.62±2.51 (101)	2.52±1.02 (62)	2.86±1.55 (249)

(n) = number of groups of two or more whales
- = no flight

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APPENDIX A

Aerial Survey Flight Captions, Survey Tracks and Sighting Summaries, 1983

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INTRODUCTION

This appendix presents the flight tracks 1 through 87, which depict aerial surveys flown over the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas between mid-April and mid-October 1983. Each flight is described in a caption, which gives the flight's objectives, survey conditions and sightings, as well as a survey track with all marine mammal sightings plotted. Each symbol on the flight track/sighting charts represents one sighting of one or more animals. Additionally, summary information on bowhead sightings is presented beneath the flight caption in the tabularized format:

T#/C#	Total number of bowheads/total number of calves seen
LAT/LONG	Location (latitude N/longitude W) in degrees, minutes and tenths of minutes
DIS	Perpendicular distance from the aircraft in meters
CUE	Sighting cue (BO=Body, BW=Blow, WD=Water Disturbance, SP=Splash, BD=Birds/Fish, MP=Mud Plumes, OS=Oil Slick, KS=Kill Site, DY=Display, IT=Ice Tracks, NA=None)
BEH	Behavior (SW=Swim, DI=Dive, RE=Rest, MI=Mill, DY=Display MT=Mate, FE=Feed, CC=Cow-Calf, SH=Spy-hop, UB=Underwater Blow, FS=Flipper Slap, TS=Tail Slap, BR=Breach, RO=Roll, NA=None)
HDG	Heading in magnetic degrees
ICE	Ice coverage in tenths
SS	Sea state (Beaufort scale)
DEPTH	Depth in meters

A dash (-) indicates data not recorded.

A seasonal summary of all marine mammal sightings by species provides an overview of sighting data for the 1983 field season (Table A-1). Species abbreviations used in flight track keys are listed in Table A-1.

Table A-1. Seasonal summary of all marine mammal sightings* by species, 1983.

SPECIES	ABR	SPRING	SUMMER	FALL	TOTAL
Bowhead Whale (Balaena mysticetus)	BH	92/223	0	116/172	208/395
Belukha Whale (Delphinapterus leucas)	BE	69/1397	2/5	314/2359	385/3761
Gray Whale (Eschrichtius robustus)	GW	0	435/1026	9/26	444/1052
Killer Whale (Orcinus orca)	OR	0	1/9	0	1/9
Bearded Seal (Erignathus barbatus)	BS	34/54	0	59/71	93/125
Ringed Seal (Pusa hispida)	RS	20/24	0	3/5	23/29
Ribbon Seal (Histriophoca fasciata)	HF	1/1	0	1/1	2/2
Walrus (Odobenus rosmarus)	WS	15/118	1/1	103/2498	119/2617
Polar Bear (Ursus maritimus)	PR	4/9	0	45/84	49/93
Unknown Cetacean	CT	0	1/1	0	1/1
Unknown Pinniped	PN	9/12	0	330/488	339/500

*In the species rows the numbers represent number sightings/number of individuals.
Abbreviations listed are those used in flight track keys.

METHODS

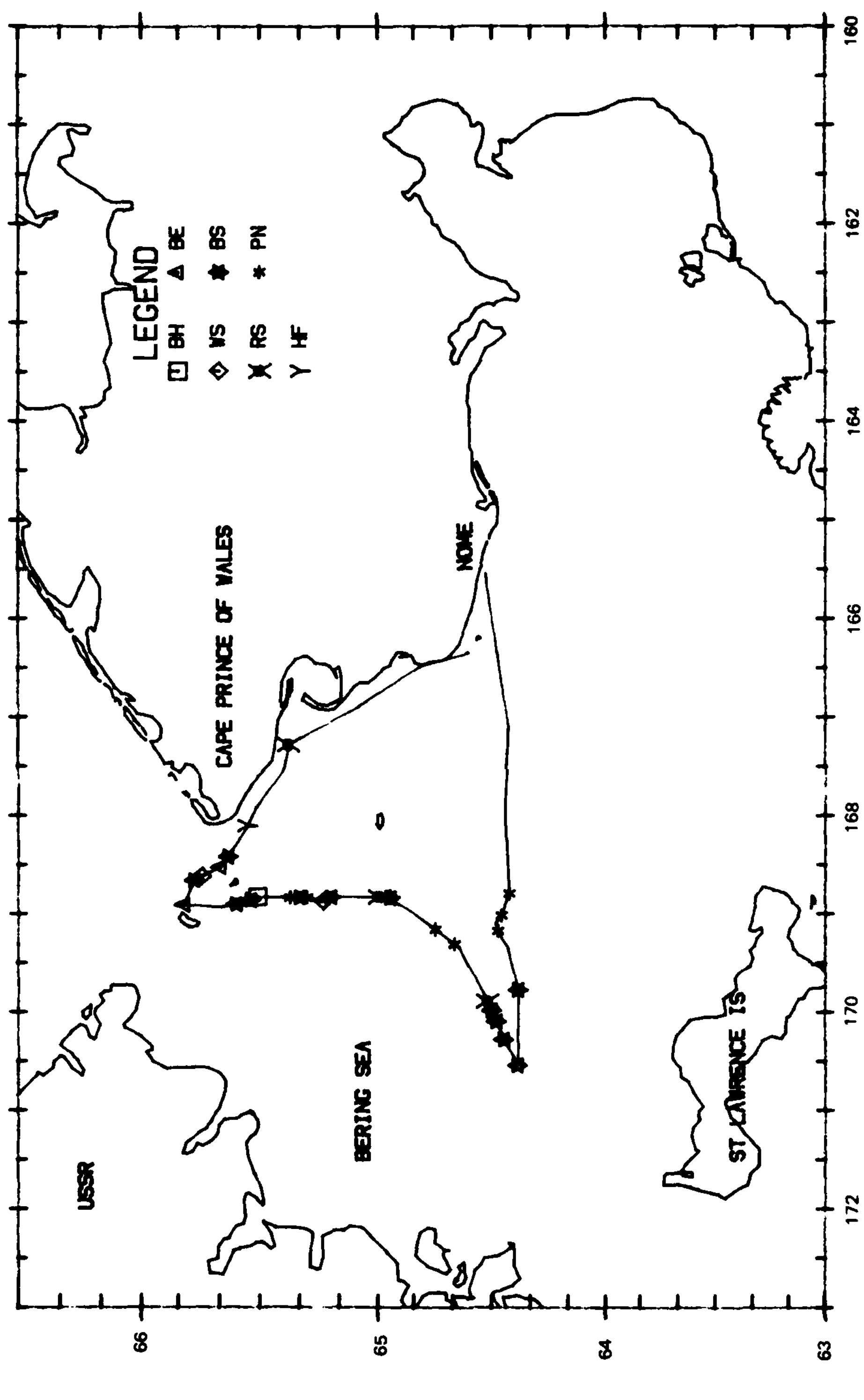
Maps were prepared using a series of computer programs consisting of BASIC subroutines implemented on a Hewlett Packard (HP)85 microcomputer connected to a HP 7470A printer/plotter. The coastlines for each map, digitized on a HP 9111A graphics tablet, were formatted to examine the principal study areas, i.e., northern Bering Sea, northeastern Chukchi Sea, and the Alaskan Beaufort Sea. As a result, a comparison of flight tracks for a given study area could be made on a visual basis over the period of the field season to evaluate ongoing patterns of animal distribution and aircraft coverage. Each map shows the flight track as a line drawn through position updates recorded on the aircraft computer system. Each animal sighting is marked with a species symbol on the flight track plot. Additional summary information provided by the computer log is reflected in the flight captions and used as a double check on total number of sightings of bowhead whales and the distances traveled on transect legs.

Flight Captions, Survey Tracks and Sightings Summaries

Flight 1: 21 April 1983

Flight was a search survey between St. Lawrence Island and Cape Prince of Wales. Weather ranged from partly cloudy to low overcast and fog, with resultant visibility ranging from unlimited to unacceptable. Ice coverage was 7/10 to 10/10, and sea state Beaufort 00 to 03. One bowhead was seen west of Cape Prince of Wales. Belukhas, ringed seals, bearded seals, walruses, a ribbon seal and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	65°30.5'	168°50.0'	-	BO	SW	010	9	B0	49

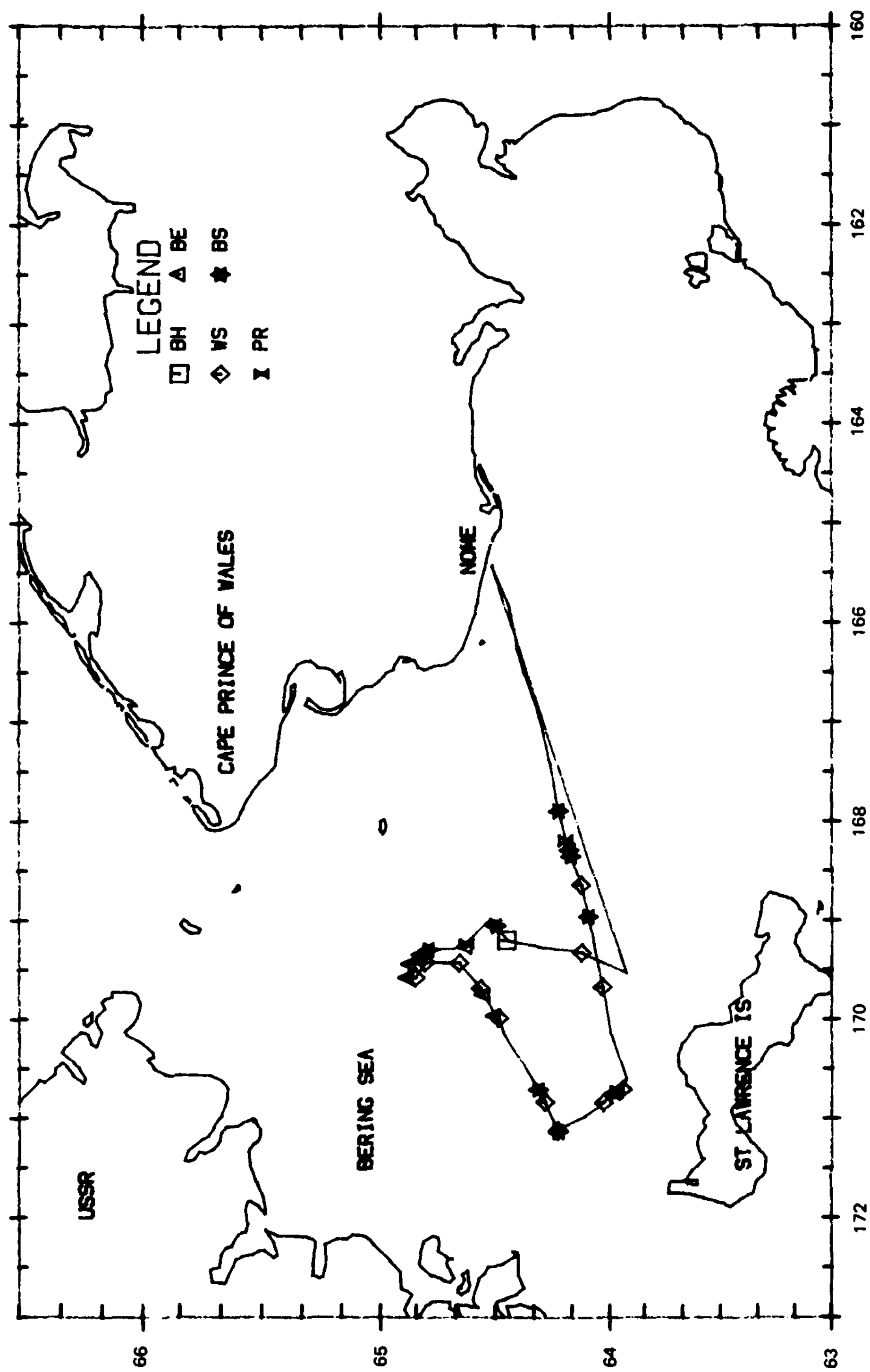


LEGEND
BH
BE
WS
BS
RS
PN
HF
CAPE PRINCE OF WALES
NOME
BERING SEA
USSR
ST LAWRENCE IS
160
162
164
166
168
170
172
66
65
64
63

Flight 2: 24 April 1983

Flight was a search survey north of St. Lawrence Island. Weather was overcast with patches of fog. Visibility ranged from unlimited to about 1 km. Ice coverage was 8/10 to 9/10 except for an area approximately 50 km northeast of Gambell that had 4/10 coverage. This open area extended westward across the International Date Line. Sea state was Beaufort 00 to 01. Two bowheads were seen as well as belukhas, bearded seals, walruses and polar bears.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	64°27.0'	169°12.6'	-	BW	SW	330	9	B0	40


LEGEND
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WS
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CAPE PRINCE OF WALES
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ST LAWRENCE IS
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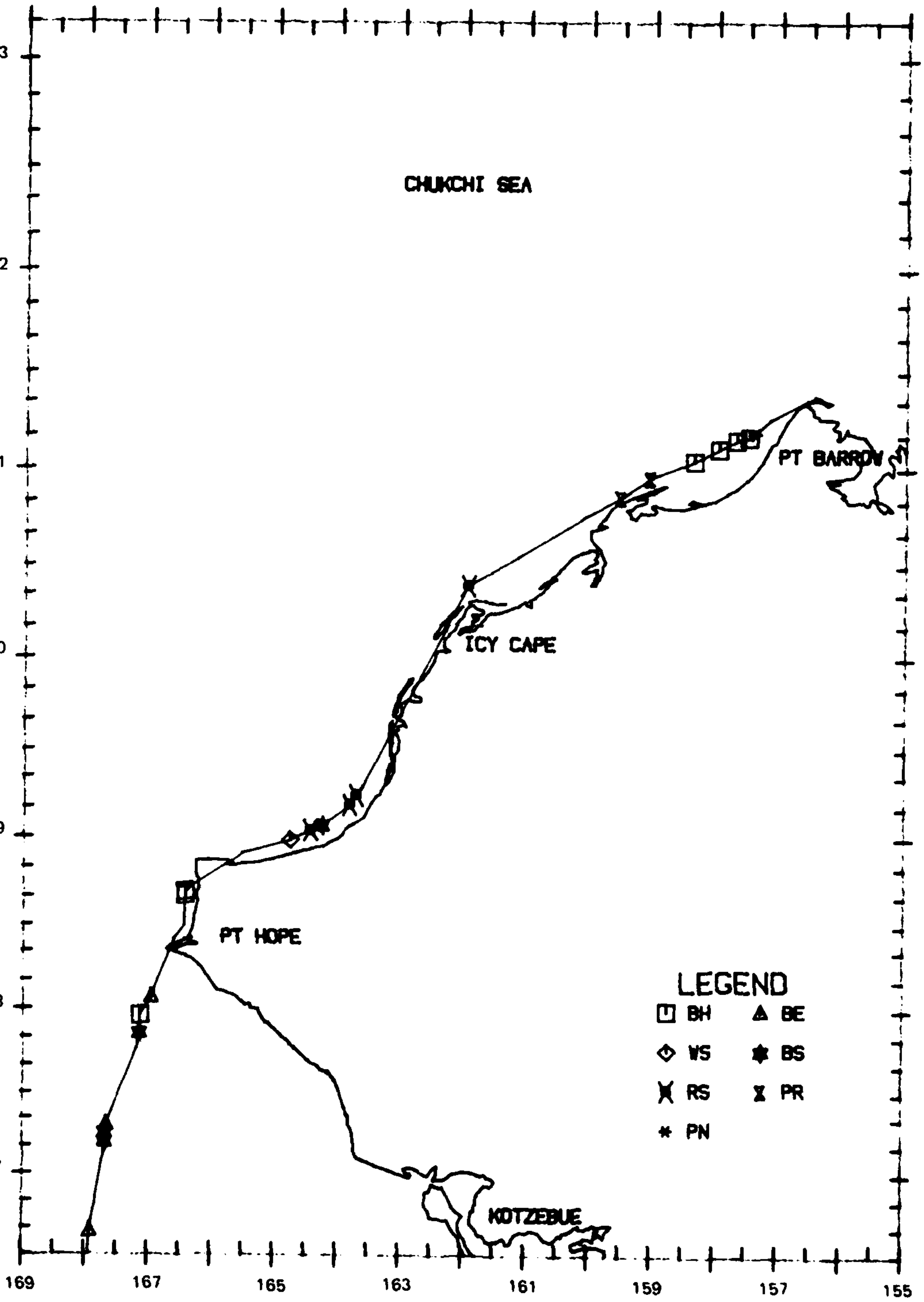
170
172

Flight 3: 25 April 1983

Flight was a coastal search survey from Nome to Pt. Barrow. Weather was overcast with areas of fog and white-out conditions. Visibility ranged from unlimited to unacceptable. Ice coverage was 7/10 to 10/10 and sea state Beaufort 00 to 01. Seventeen bowheads were seen with one pair possibly mating. Belukhas, ringed seals, bearded seals, walruses, an unidentified pinniped and polar bears were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	67°57.9'	167°07.9'	-	BO	SW	010	9	B0	48
1/0	68°40.6'	166°25.6'	-	BO	SW	020	8	B0	35
9/0	68°41.9'	166°25.6'	-	BO	MT	020	8	B0	35
1/0	71°02.8'	158°21.6'	-	BO	SW	-	9	B0	27
1/0	71°0.62'	157°58.0'	-	BW	SW	-	8	B0	27
3/0	71°08.8'	157°41.8'	-	BO	SW	-	8	B0	29
1/0	71°09.8'	157°29.8'	-	BO	SW	-	7	B0	29



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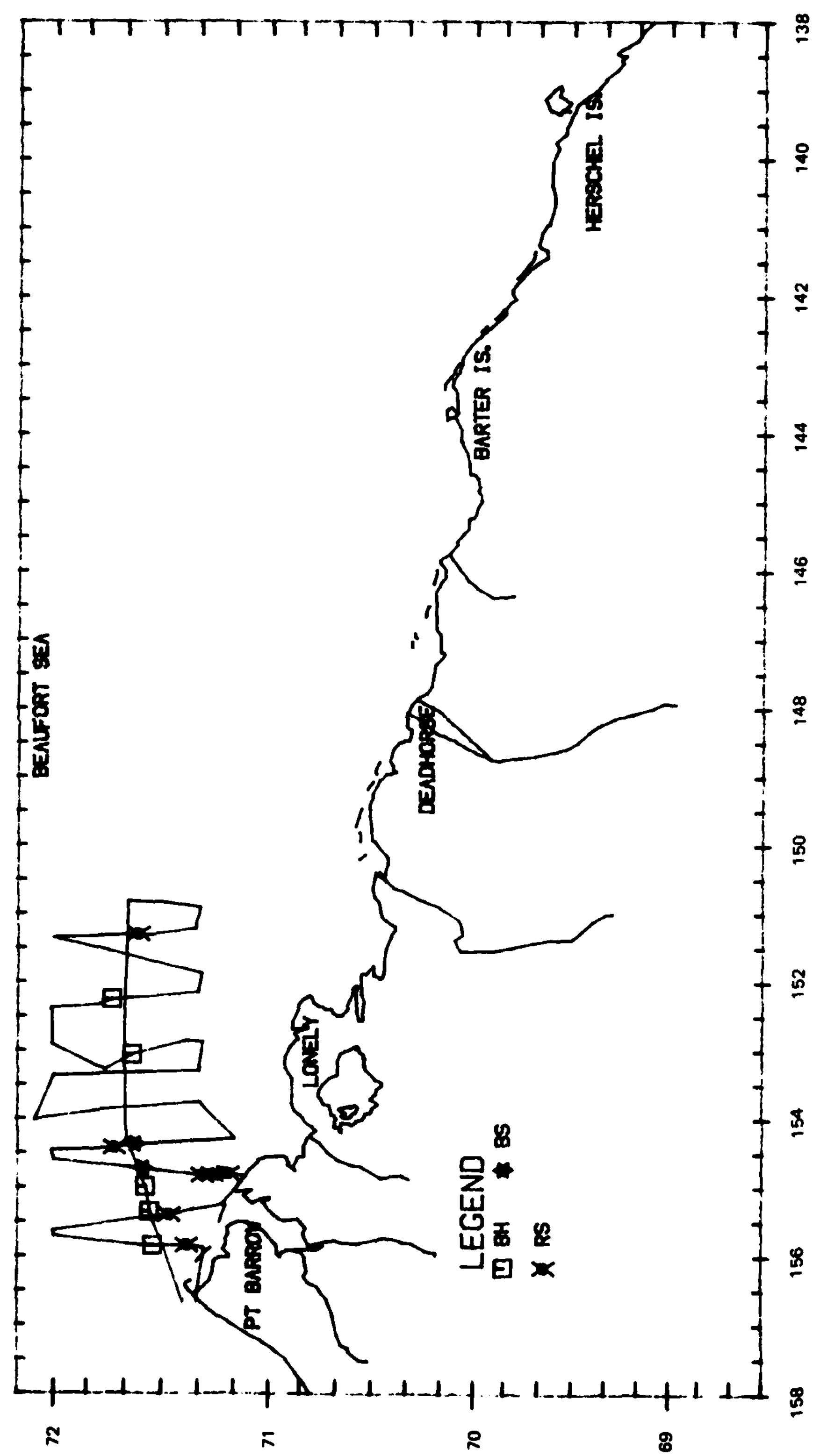
163
161
159
157
155
CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
KOTZEBUE
LEGEND
BH
BE
WS
BS
RS
PR
PN

Flight 4: 28 April 1983

Flight was a transect survey in blocks 12 and 11 with a search survey back to Pt. Barrow. Weather ranged from clear to fog, resulting in unlimited to less than 1 km visibility. Ice coverage ranged from 1/10 (in lead) to 10/10, with an average 9/10 to 10/10 cover in the survey blocks. Sea state was Beaufort 02 in the lead, Beaufort 00 elsewhere. Eight bowheads were seen; one breached four times. Bearded seals and ringed seals were also seen.

T#/C#	LAT	LONG	DIS	CUE	BWH	HDG	ICE	SS	DEPTH
1/0	71°32.5'	155°50.0'	186	BW	SW	070	1	B2	24
1/0	71°38.0'	153°02.9'	402	SP	BR	060	9	B0	57
1/0	71°43.4'	152°14.5'	782	BO	SW	190	9	B0	373
3/0	71°34.5'	154°58.4'	332	BO	SW	060	9	B0	42
2/0	71°33.3'	155°20.2'	201	BO	SW	060	9	B0	37


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
BH
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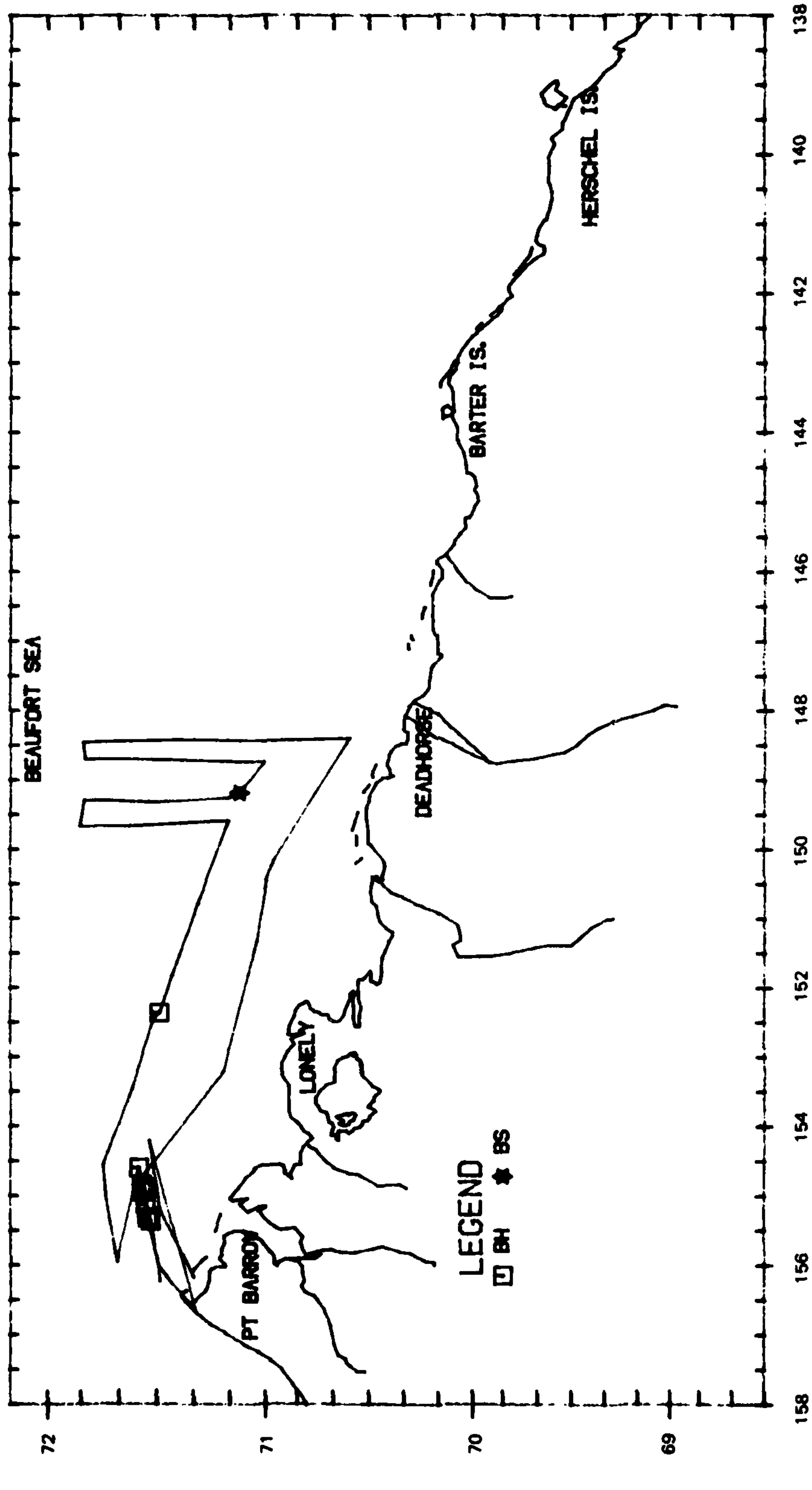
Flight 5: 29 April 1983

Flight was a search in the lead northeast of Pt. Barrow, a transect survey in the western half of blocks 2 and 10 and an ice reconnaissance survey in blocks 1 and 3. Weather ranged from clear to overcast with intermittent haze. Visibility was unlimited. Ice coverage was 9/10 to 10/10 except in the open water lead northeast of Pt. Barrow where sea state was a Beaufort 04. Nineteen bowheads and one bearded seal were seen. One pair of bowheads appeared to be mating.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°32.4'	155°18.9'	-	BO	DI	-	6	B4	42
1/0	71°33.3'	154°55.1'	457	BO	SW	055	5	B4	42
2/0	71°33.8'	154°56.4'	581	BO	SW	055	5	B4	46
3/0	71°33.7'	154°55.6'	214	BO	MT	020	5	B4	46
2/0	71°33.4'	154°52.9'	634	BO	SW	055	5	B4	42
1/0	71°33.9'	154°50.6'	406	BO	SW	050	5	B4	40
3/0	71°34.7'	154°35.7'	320	BO	SW	055	5	B4	42
3/0	71°29.2'	152°21.4'	528	BO	SW	050	9	B0	42
2/0	71°32.9'	155°07.2'	749	BO	SW	060	8	B4	46
1/0	71°31.6'	155°21.6'	1257	BO	SW	050	8	B4	42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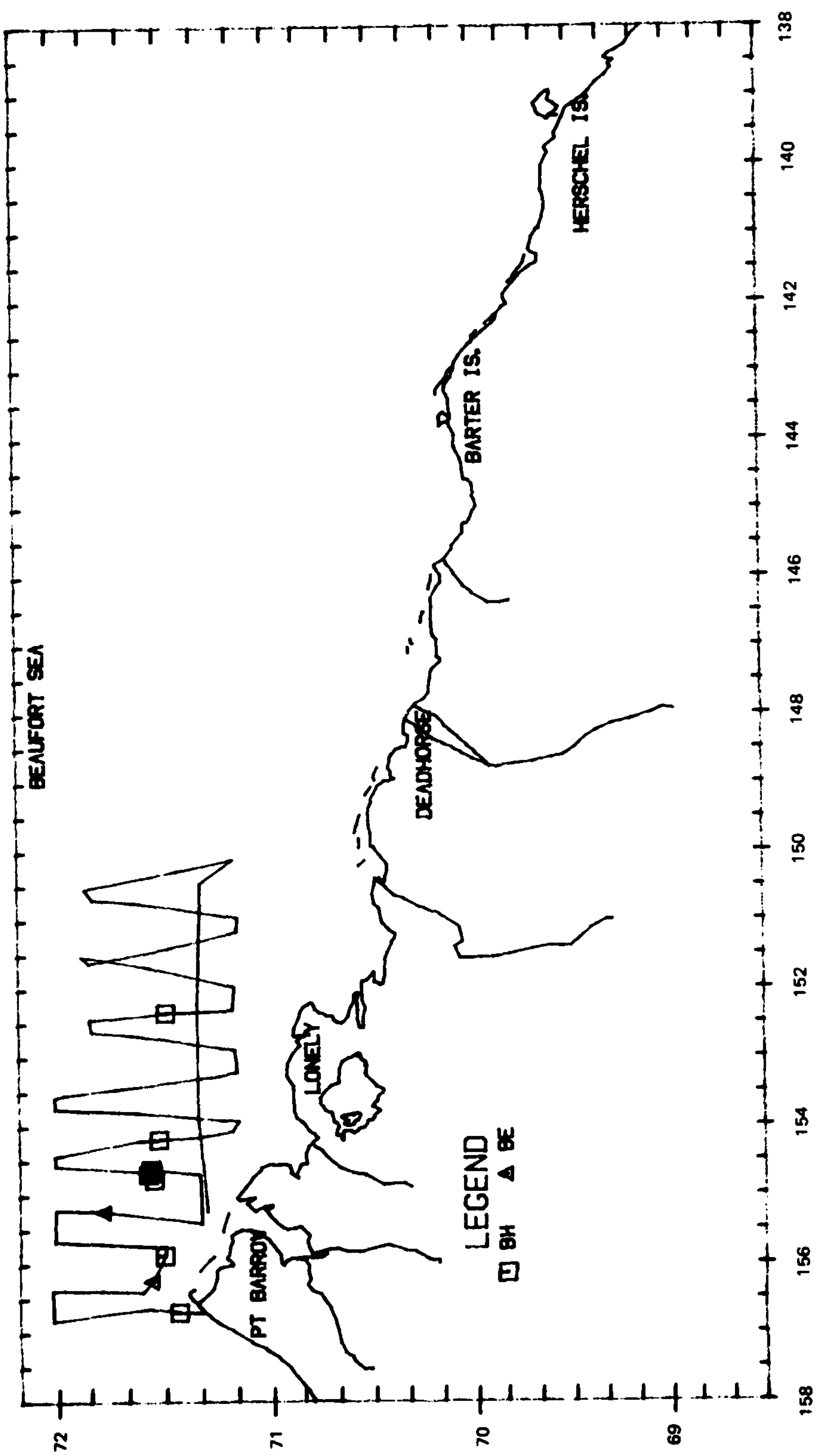
Flight 6: 30 April 1983

Flight was a transect survey in blocks 12 and 11 with a search back to Pt. Barrow. Weather was clear with some haze, and visibility was generally unlimited. Ice coverage was 9/10 to 10/10 except in the open water lead northeast of Pt. Barrow where sea state was Beaufort 01 to 02. Eighteen bowheads and several belukhas were seen. One pair of bowheads appeared to be mating. One sonobuoy was dropped and a small sample of bowhead and bearded seal calls were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	71°26.2'	156°41.5'	976	BO	SW	060	8	B1	88
2/0	71°30.2'	155°52.0'	610	BO	SW	060	8	B1	18
4/0	71°33.8'	154°36.6'	-	BO	SW	060	2	B1	40
2/0	71°32.9'	154°45.8'	-	BO	MT	-	2	B1	42
1/0	71°34.5'	154°40.8'	-	BO	SW	240	1	B1	46
4/0	71°33.5'	154°39.3'	-	BO	MI	060	1	B1	33
1/0	71°31.4'	154°10.8'	427	BO	SW	060	9	B1	31
2/0	71°29.3'	152°20.2'	708	BO	SW	090	9	B0	183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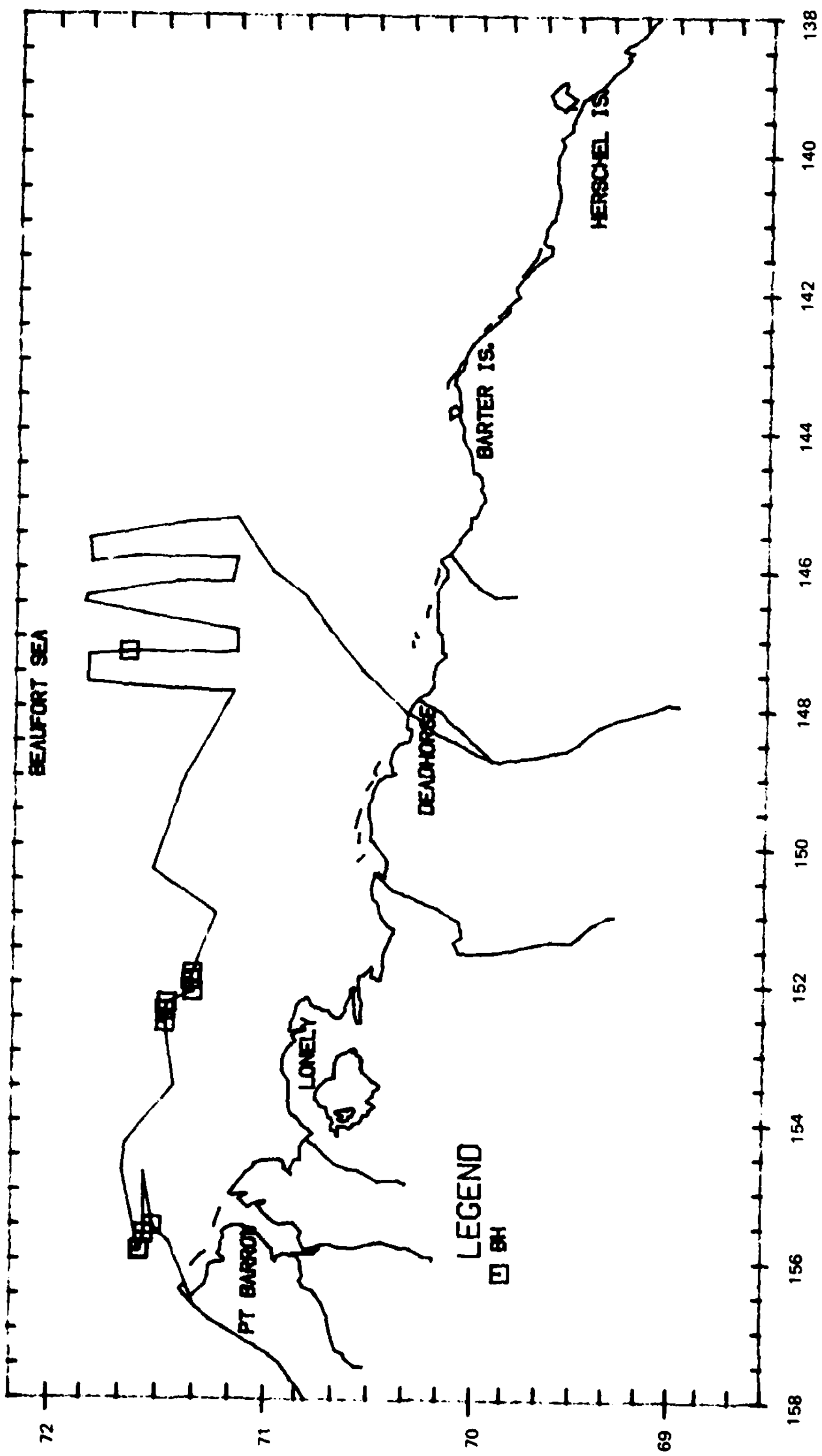
Flight 7: 1 May 1983

Flight was a search survey of the lead northeast of Pt. Barrow and a transect survey in blocks 2, 10, and 9. Weather was clear and visibility was unlimited. Ice coverage was 9/10 to 10/10 except in the open water lead northeast of Pt. Barrow where sea state was a Beaufort 03. Thirty-four bowheads were seen. Four pair of bowheads appeared to be mating; breaching and tail slapping were also seen. A sonobuoy was dropped and bowhead and bearded seal calls were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°31.1'	155°30.1'	610	BO	SW	050	1	B3	24
2/0	71°33.4'	155°37.1'	545	BO	SW	060	1	B3	154
3/0	71°34.5'	155°50.9'	850	BO	MT	-	3	B3	179
4/0	71°34.8'	155°52.0'	-	BO	MT	-	4	B3	179
4/0	71°28.3'	152°33.5'	436	BO	SW	070	8	B3	177
2/0	71°28.2'	152°22.7'	255	BO	SW	060	8	B3	177
12/0	71°27.6'	152°15.9'	-	SP	MT	060	4	B3	183
2/0	71°20.6'	152°06.6'	805	BO	SW	060	4	B3	159
1/0	71°21.1'	151°56.5'	1382	BO	SW	060	4	B3	55
2/0	71°20.9'	151°51.0'	734	BO	SW	060	4	B3	55
1/0	71°38.9'	147°11.5'	1191	SP	SW	060	9	B2	2817



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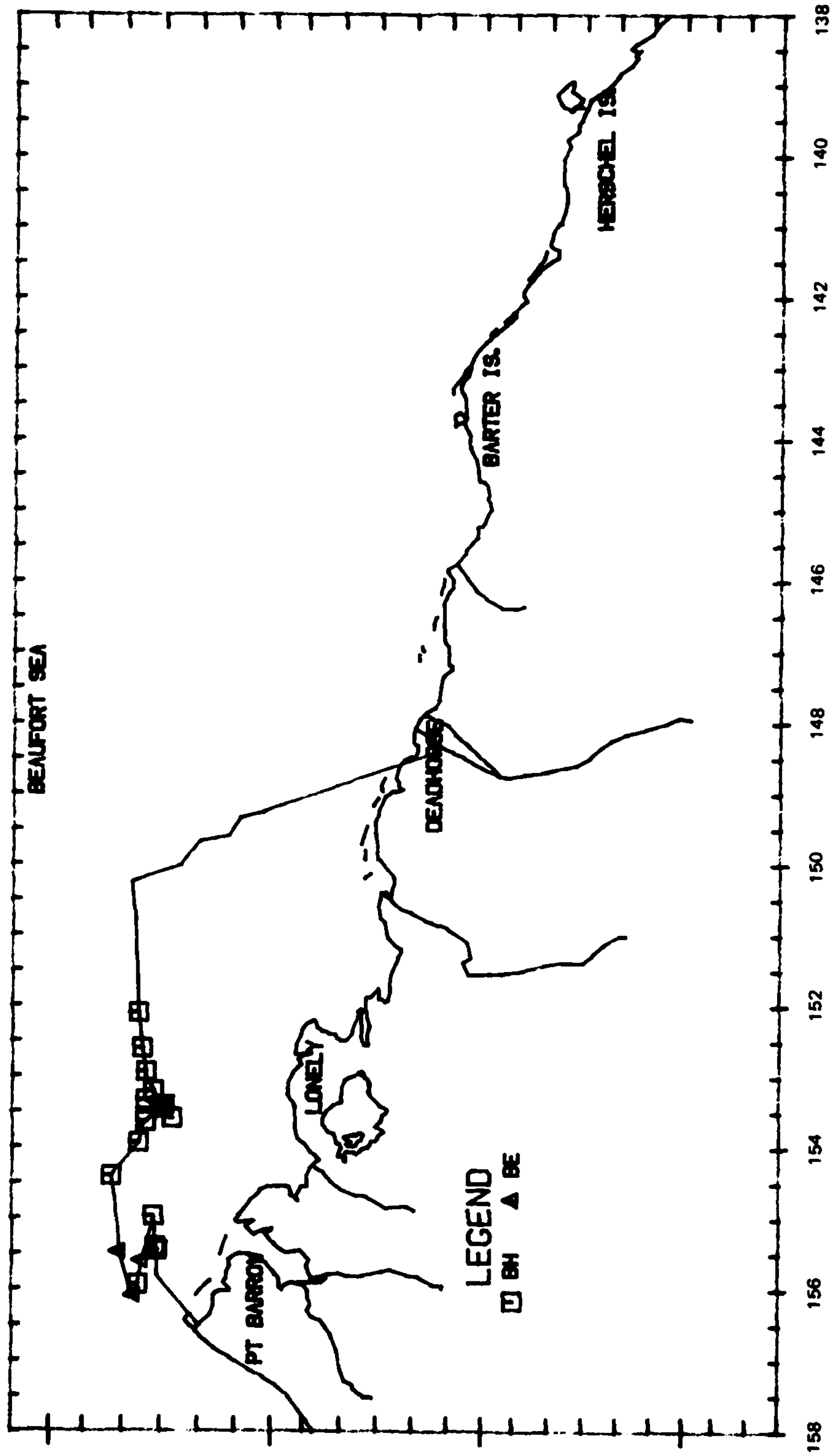
Flight 8: 2 May 1983

Flight was a search survey in blocks 12 and 11. Weather was clear, visibility, unlimited. Ice coverage was 9/10 to 10/10 except in the nearshore open water lead where sea state was Beaufort 02. Fifty-three bowheads were seen, with seven groups of 4 to 8 whales. Three pairs of bowheads appeared to be mating. Belukhas were also seen. Two sonobuoys were dropped and sounds of bowheads, belukhas, and bearded seals were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°31.0'	155°27.0'	610	SP	SW	060	8	B3	49
1/0	71°31.6'	155°24.0'	1314	SP	DI	060	8	B3	37
1/0	71°32.0'	154°58.0'	1358	BO	SW	075	8	B3	42
6/0	71°36.0'	155°56.0'	151	BO	SW	030	8	B3	221
8/0	71°43.0'	154°24.0'	739	SP	SW	040	9	B2	42
7/0	71°36.0'	153°56.0'	508	SP	DI	060	9	B2	48
8/0	71°34.0'	153°38.0'	63	BW	SW	060	7	B3	49
1/0	71°29.0'	153°24.0'	158	BW	DI	260	7	B3	55
1/0	71°27.0'	153°35.0'	213	SP	SW	060	7	B3	49
6/0	71°34.0'	153°20.0'	739	BW	MT	060	7	B3	57
4/0	71°30.0'	153°27.0'	-	SP	SW	030	5	B3	55
1/0	71°32.0'	153°12.0'	-	BO	DI	030	5	B3	68
4/0	71°34.0'	152°56.0'	-	BO	MT	-	9	B3	46
3/0	71°35.0'	152°36.0'	-	SP	SW	-	9	B3	183
1/0	71°36.0'	152°06.0'	-	BO	SW	-	9	B3	274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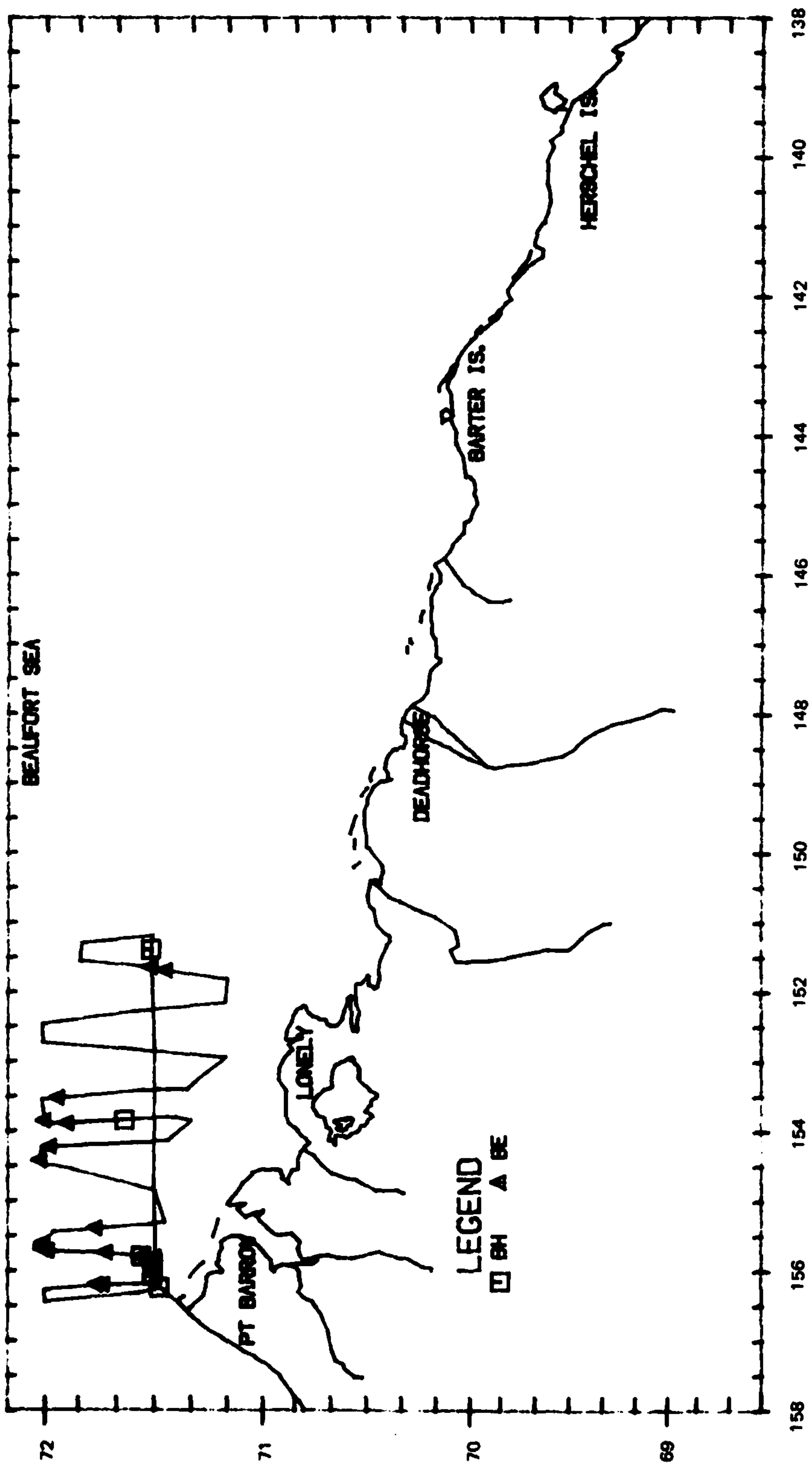
Flight 9: 3 May 1983

Flight was a transect survey in block 12 and 11 with a search survey return to Pt. Barrow. Weather was clear, visibility, unlimited. Sea state in the nearshore open water lead (which was closing off) was Beaufort 00 to 03. Fifteen bowheads were seen with one pair apparently mating. Belukhas were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°28.6'	156°14.4'	713	BO	SW	030	9	B1	18
2/0	71°30.4'	156°03.7'	1328	BO	SW	070	5	B3	18
2/0	71°33.5'	155°47.2'	527	BO	SW	300	5	B3	24
4/0	71°37.9'	153°50.1'	761	BO	MT	-	9	B0	48
4/0	71°30.8'	151°23.1'	256	BW	SW	090	9	B0	549
2/0	71°30.4'	155°53.1'	-	BO	SW	090	9	B0	18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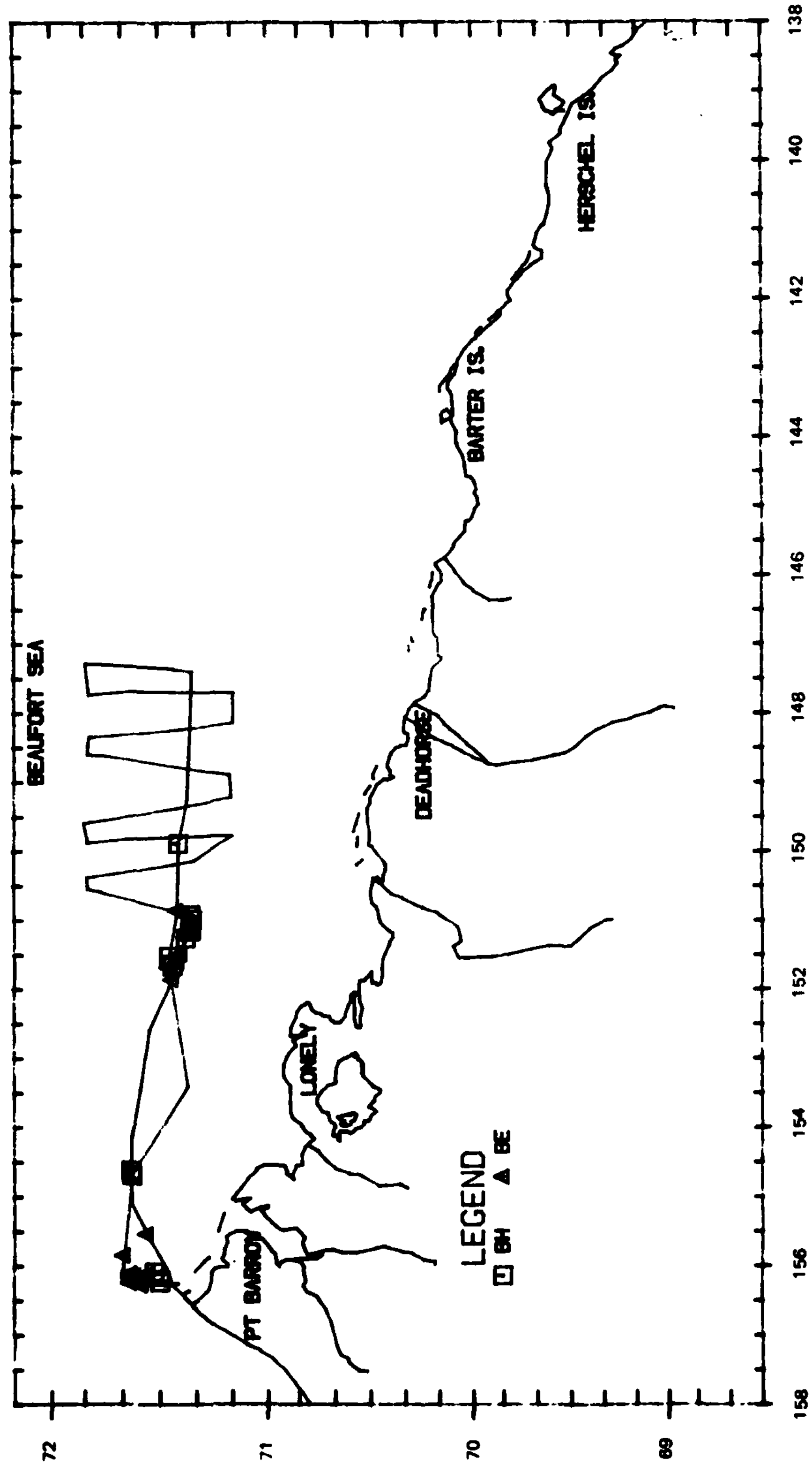
Flight 10: 4 May 1983

Flight was a transect survey of blocks 11 and 10 with a search survey in block 12 including two lines directly north of the North Slope Borough ice camps conducting the bowhead census. Weather was clear with unlimited visibility. Sea state was a Beaufort 00 to 03 in the nearshore lead. Thirty-one bowheads were seen with one pair possibly mating. Whales seen east of 151°W longitude were in very small cracks (0.5 km) and open water ponds. Belukhas were also seen. A sonobuoy was dropped and bowhead and belukha sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°37.8'	154°37.5'	732	BO	SW	050	9	B3	35
3/0	71°22.9'	151°15.4'	868	BO	SW	-	9	B1	64
1/0	71°21.7'	151°09.4'	-	BO	SW	040	9	B1	64
1/0	71°21.5'	151°06.0'	631	BO	SW	060	9	B1	64
4/0	71°21.5'	151°08.3'	-	BO	SW	060	9	B1	64
2/0	71°21.2'	150°58.6'	1131	BO	SW	120	9	B1	64
2/0	71°21.5'	150°54.9'	-	BW	SW	090	9	B1	64
9/0	71°24.8'	149°53.1'	1390	BO	SW	-	9	B1	640
2/0	71°27.5'	151°31.1'	374	BW	SW	-	9	B1	329
2/0	71°26.6'	151°39.6'	636	BW	MT	090	9	B1	329
1/0	71°37.5'	154°41.3'	-	BO	SW	060	9	B0	46
1/0	71°31.5'	156°05.4'	756	BO	DI	-	9	B2	24
2/0	71°29.8'	156°13.9'	860	BO	SW	030	9	B1	18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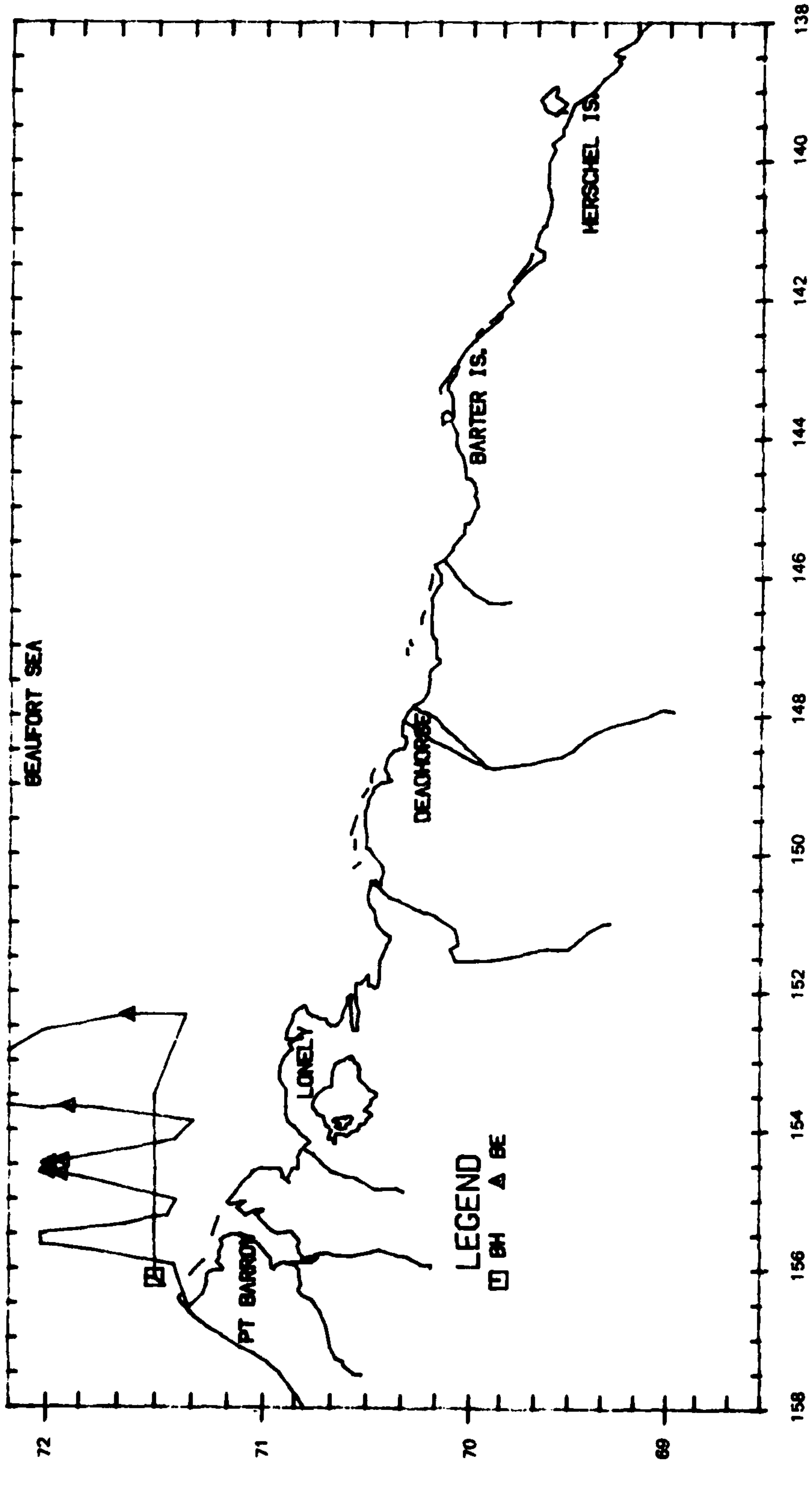
Flight 11: 5 May 1983

Flight was a transect survey in block 12 and 11 with an extension of a transect leg in block 11 made to 72°30'N to assess ice conditions. Weather was clear and visibility, unlimited. Ice coverage was 9/10 and 10/10 with a sea state of Beaufort 00 to 01. One bowhead was seen northeast of Pt. Barrow. Belukhas were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°30.0'	156°08.1'	812	BO	SW	030	9	B0	18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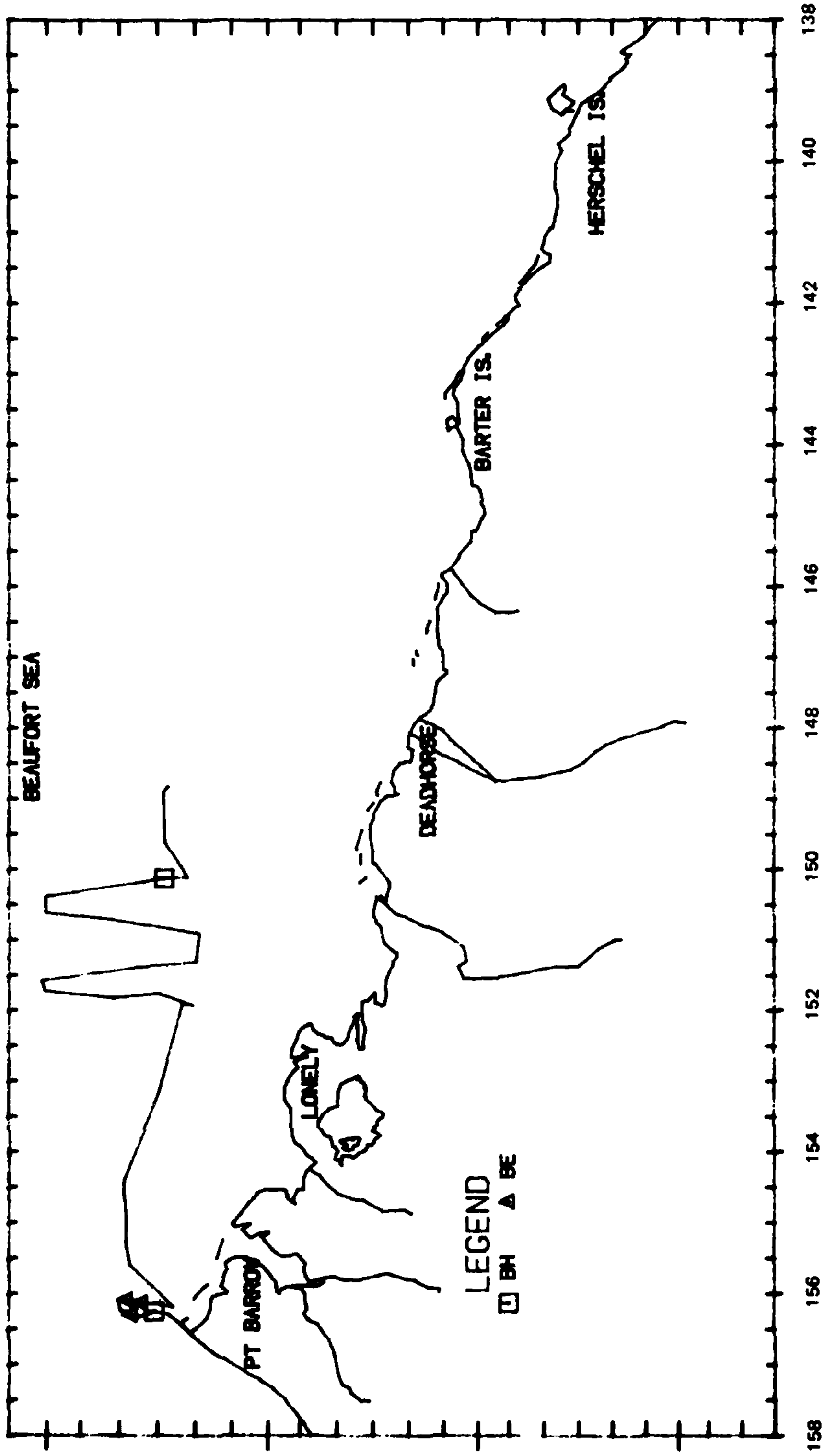
Flight 12: 6 May 1983

Flight was a search survey north of the original ice census camp perch and a transect survey of block 11 enroute to Deadhorse. A transect survey in block 10 was aborted due to fog. Weather ranged from clear to fog, resulting in unlimited to unacceptable visibility. Ice coverage was 9/10 to 10/10 with a sea state of Beaufort 00. Two bowheads and several belukhas were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DSEPTH
1/0	71°30.7'	156°15.6'	792	BO	SW	300	9	B0	18
1/0	71°28.1'	150°08.0'	-	BO	SW	090	9	B0	1463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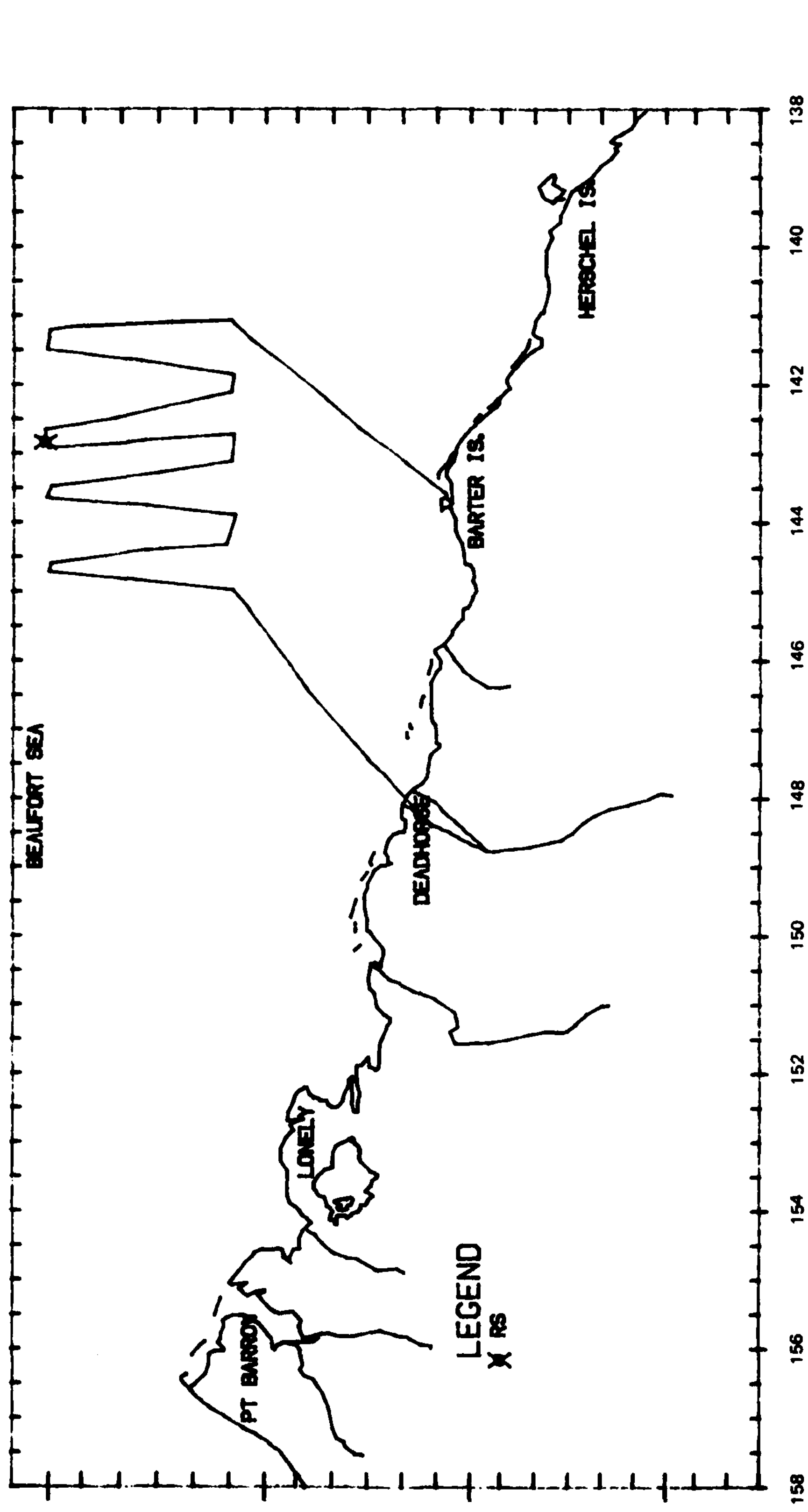
Flight 13: 8 May 1983

Flight was a transect survey in blocks 9 and 8. Weather was clear with patchy fog. Visibility ranged from unlimited to 2 km. Ice coverage was greater than 9/10 with grease ice nearly covering the cracks that existed. A ringed seal was seen.



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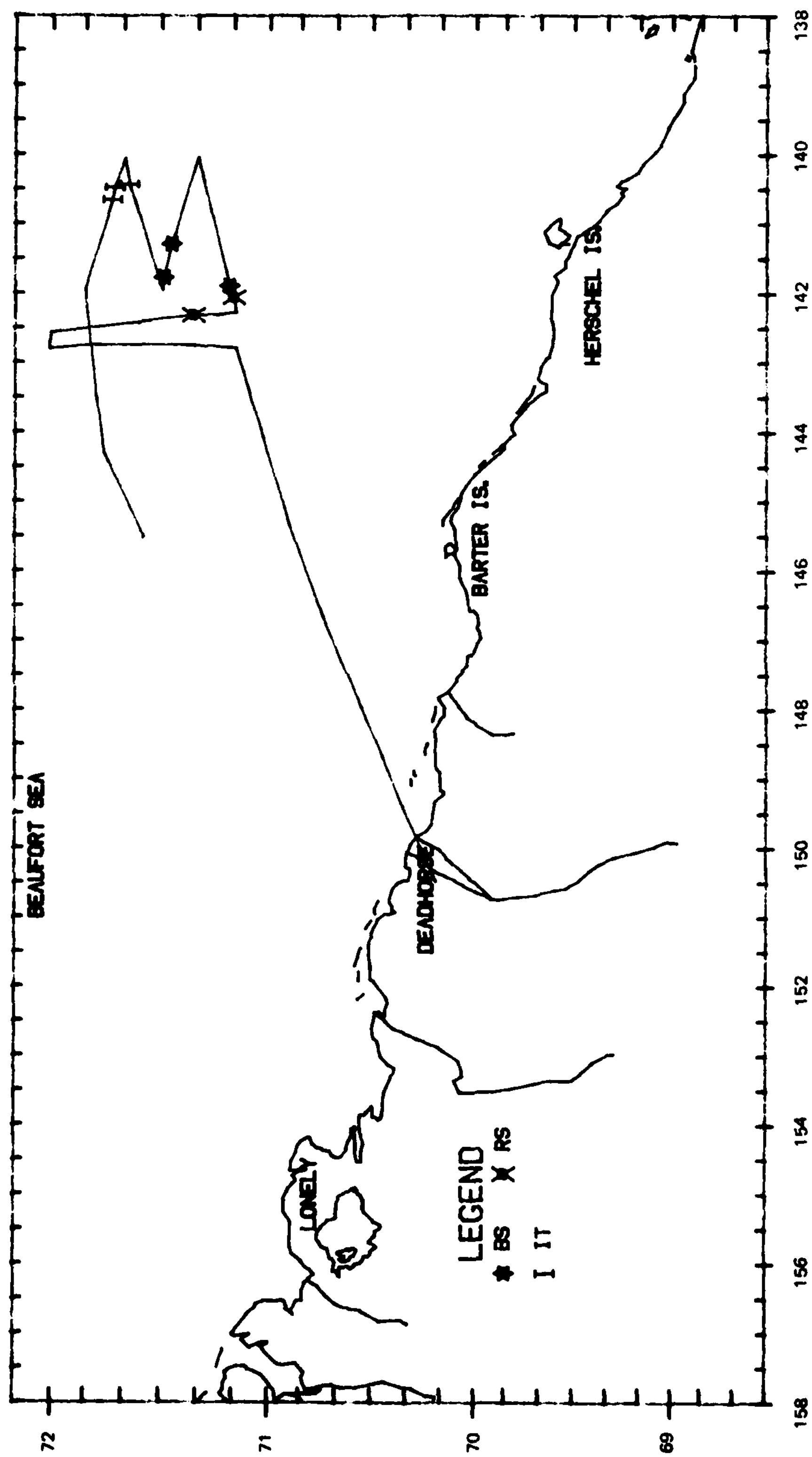
Flight 14: 9 May 1983

Flight was a transect survey in the eastern third of block 8 with east to west search survey legs extending to 138°W longitude. Weather was overcast with areas of fog. Visibility ranged from 15 km to unacceptable. Ice coverage was generally greater than 9/10 with grease ice nearly covering the cracks that existed. Though no bowheads were seen, ice tracks (IT) possibly made by bowheads were seen at approximately 71°40'N latitude, 138°30'W longitude. Bearded seals and ringed seals were seen.



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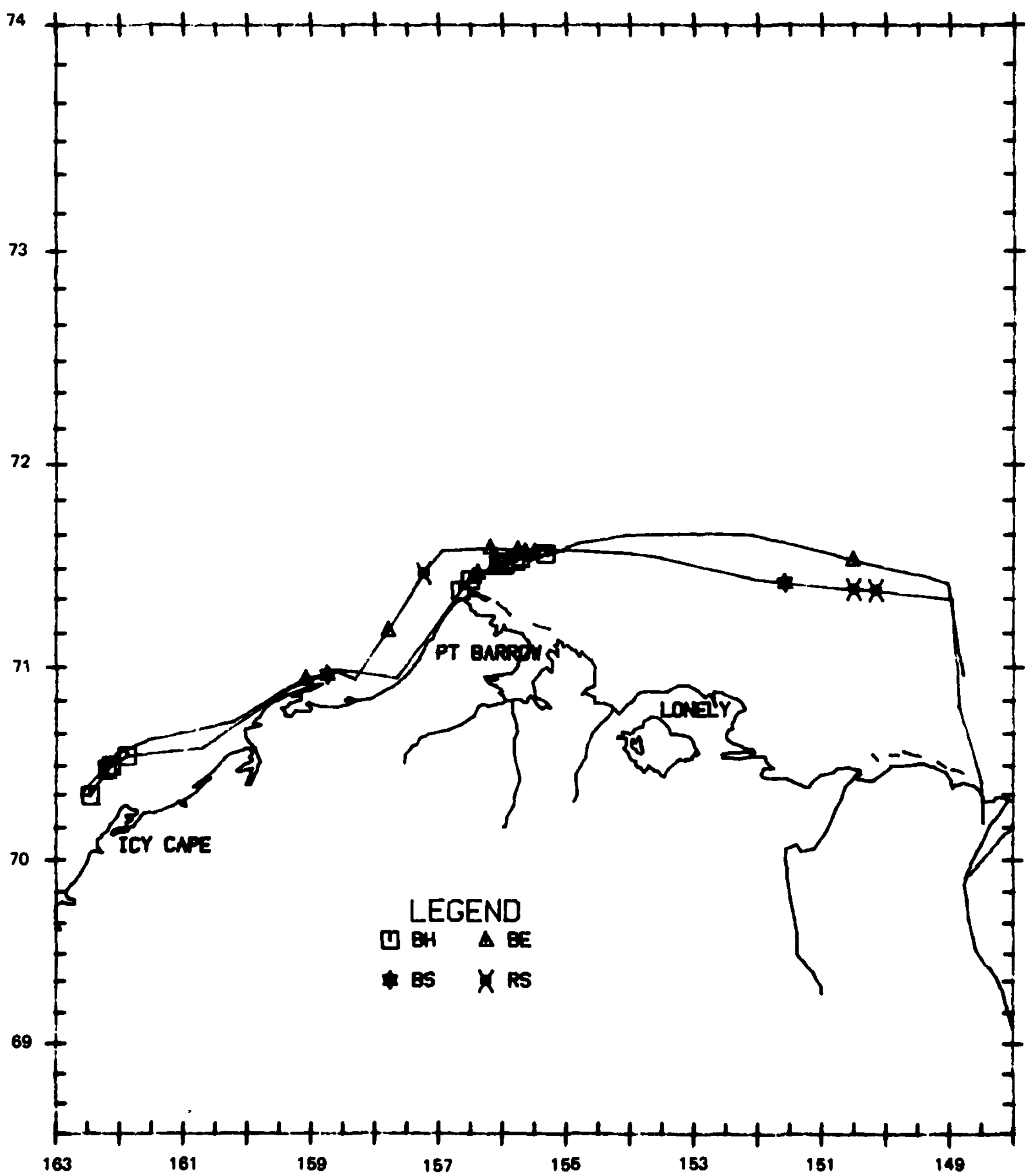
Flight 15: 10 May 1983

Flight was a search survey between Deadhorse and Pt. Barrow in the Beaufort Sea, and a search of the nearshore lead in the Chukchi Sea south to Icy Cape. Weather was low overcast with patchy fog, resulting in visibility ranging from 2 km to unlimited. Ice coverage was greater than 9/10 from Deadhorse to 154°W longitude, 9/10 around Barrow, 7/10 south to Wainwright and open (less than 1/10) nearshore at Icy Cape. Sea state ranged between Beaufort 00 to 03. Twenty-two bowheads were seen, four just north of Icy Cape and 18 north and east of Pt. Barrow. One pair of bowheads appeared to be mating. Belukhas, bearded seals and ringed seals were seen. A sonobuoy was dropped and bowhead and belukha sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°19.6'	162°26.5'	766	BW	SW	050	8	B2	18
1/0	70°27.5'	162°10.4'	-	BO	SW	150	8	B2	18
1/0	70°30.0'	162°06.8'	915	BO	SW	030	8	B2	18
1/0	70°33.1'	161°52.1'	1650	BW	SW	050	8	B2	18
2/0	71°22.4'	156°38.6'	-	BO	SW	030	5	B2	18
1/0	71°25.4'	156°29.1'	-	BO	DI	-	5	B2	18
1/0	71°29.9'	156°02.6'	808	SP	DI	-	5	B2	18
4/0	71°31.1'	155°57.3'	-	BO	SW	060	5	B2	18
2/0	71°31.8'	155°56.8'	-	BO	SW	060	7	B2	18
2/0	71°32.3'	155°46.7'	-	BO	SW	160	7	B2	24
1/0	71°33.2'	155°42.1'	-	BO	SW	060	7	B2	24
5/0	71°34.5'	155°18.2'	-	SP	MT	060	9	BO	20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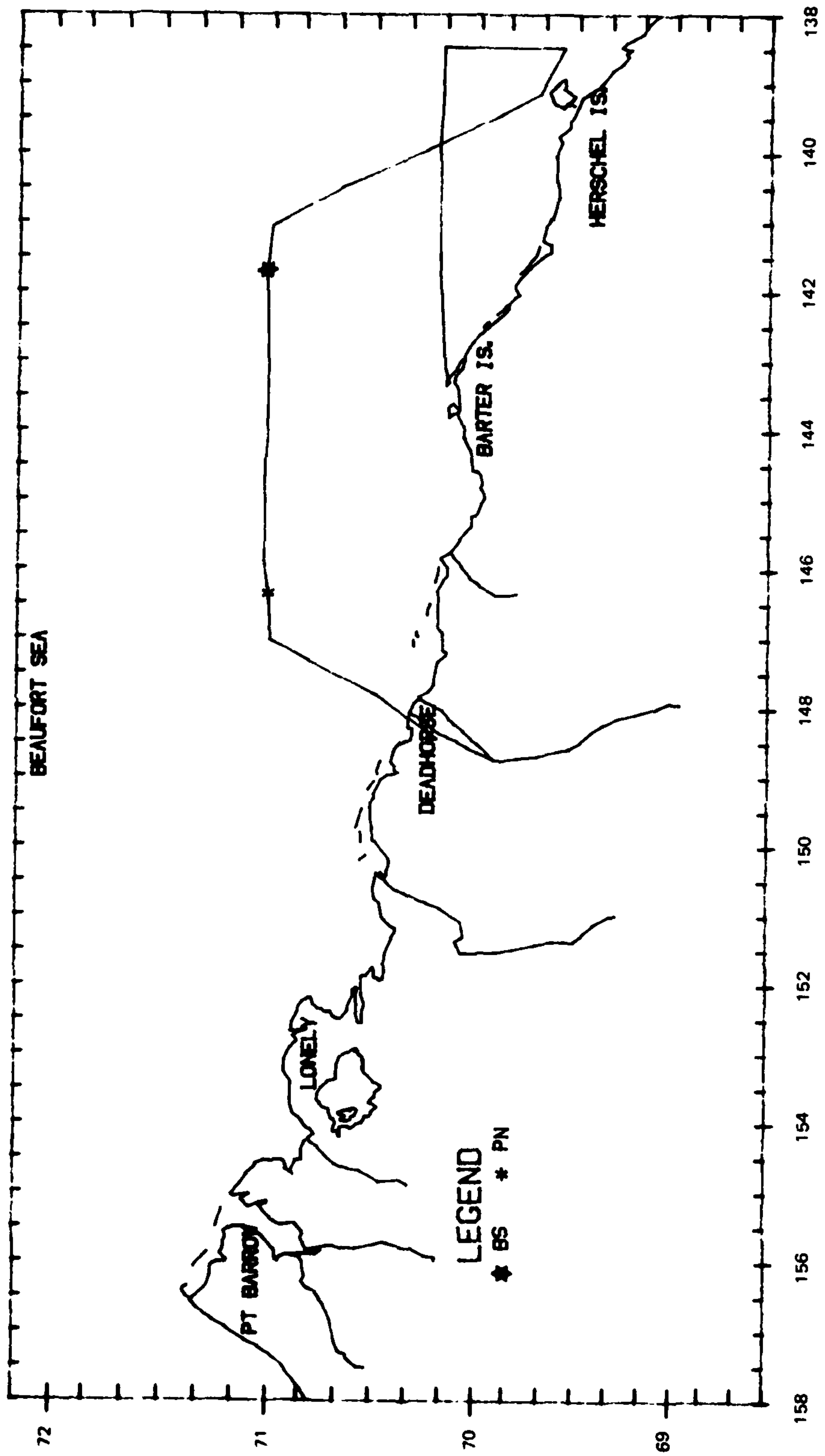
Flight 16: 11 May 1983

Flight was a search survey through blocks 5, 6, and 7 east to 138°30'W, south to Herschel Island, and a return to Deadhorse. Weather was clear with some haze and occasional patchy fog. Visibility ranged from unlimited to 2 km. Ice coverage was 9/10 to solid with a sea state of Beaufort 00 to 01 in open water areas. Two bearded seals and an unidentified pinniped were seen.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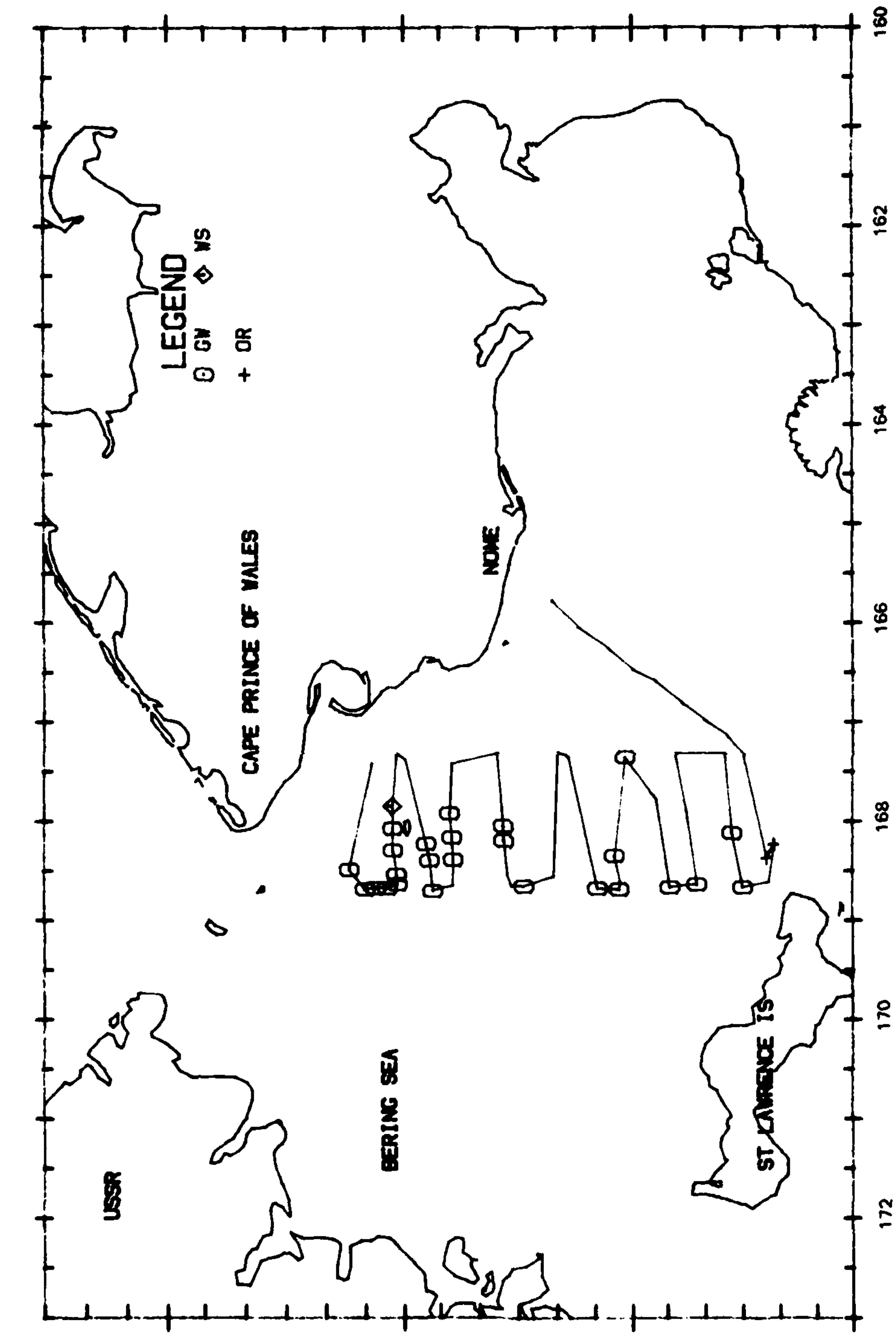
Flight 17: 20 July 1983

Flight was a transect survey of block C. Weather was generally overcast with patchy fog and visibility ranging from unlimited to 1 km. Sea state was Beaufort 00 to 01. Nine killer whales were seen near a fog edge. There were 282 gray whales and one walrus seen. One sonobuoy was dropped but no sounds were recorded.



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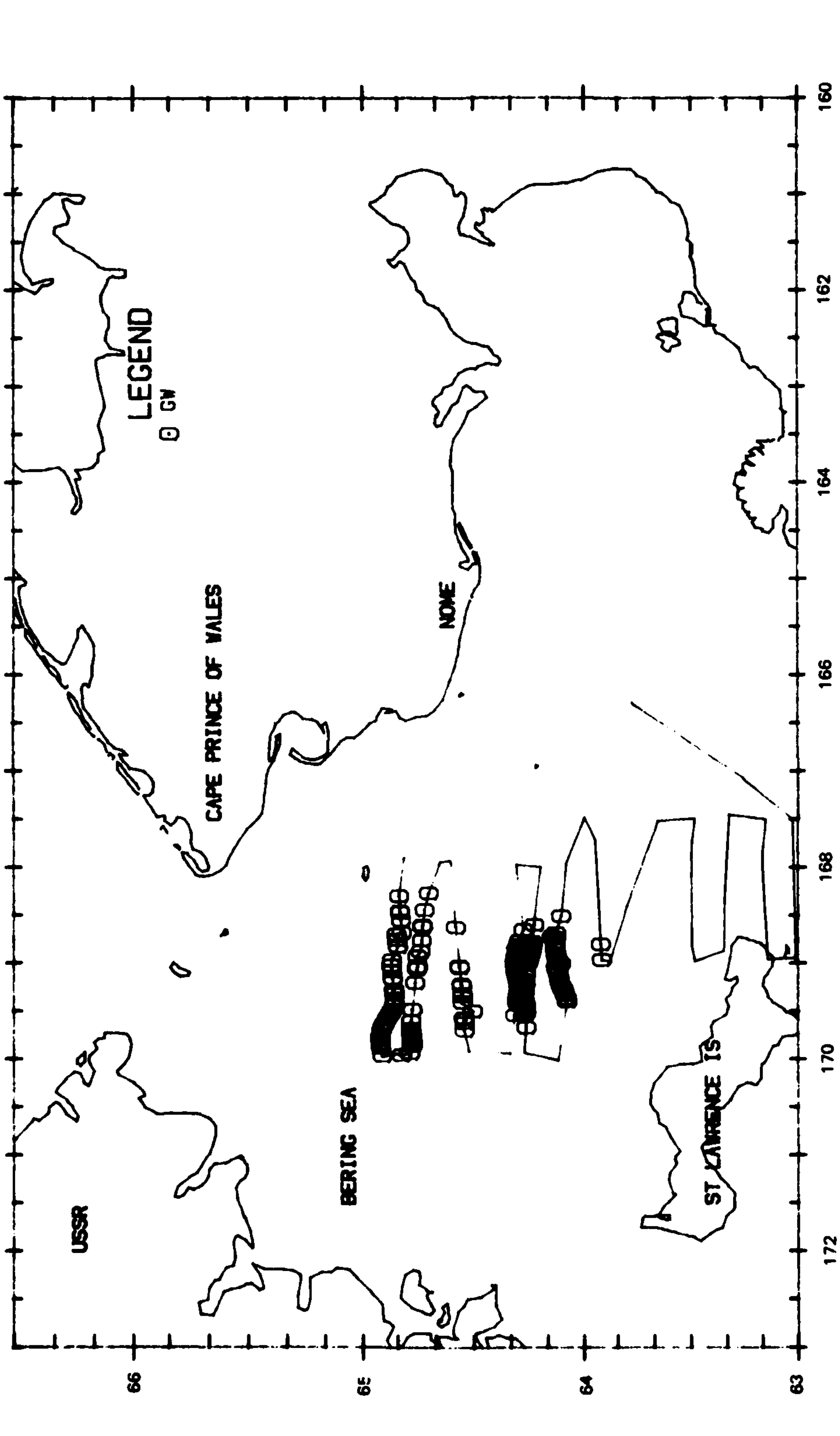
Flight 18: 21 July 1983

Flight was a transect survey of part of block C and block E. Weather was clear with generally unlimited visibility. Sea state was Beaufort 02. There were 319 gray whales seen concentrated between 64°N to 65°N and 168°W to 170°W. One cow-calf pair and one social pair were seen.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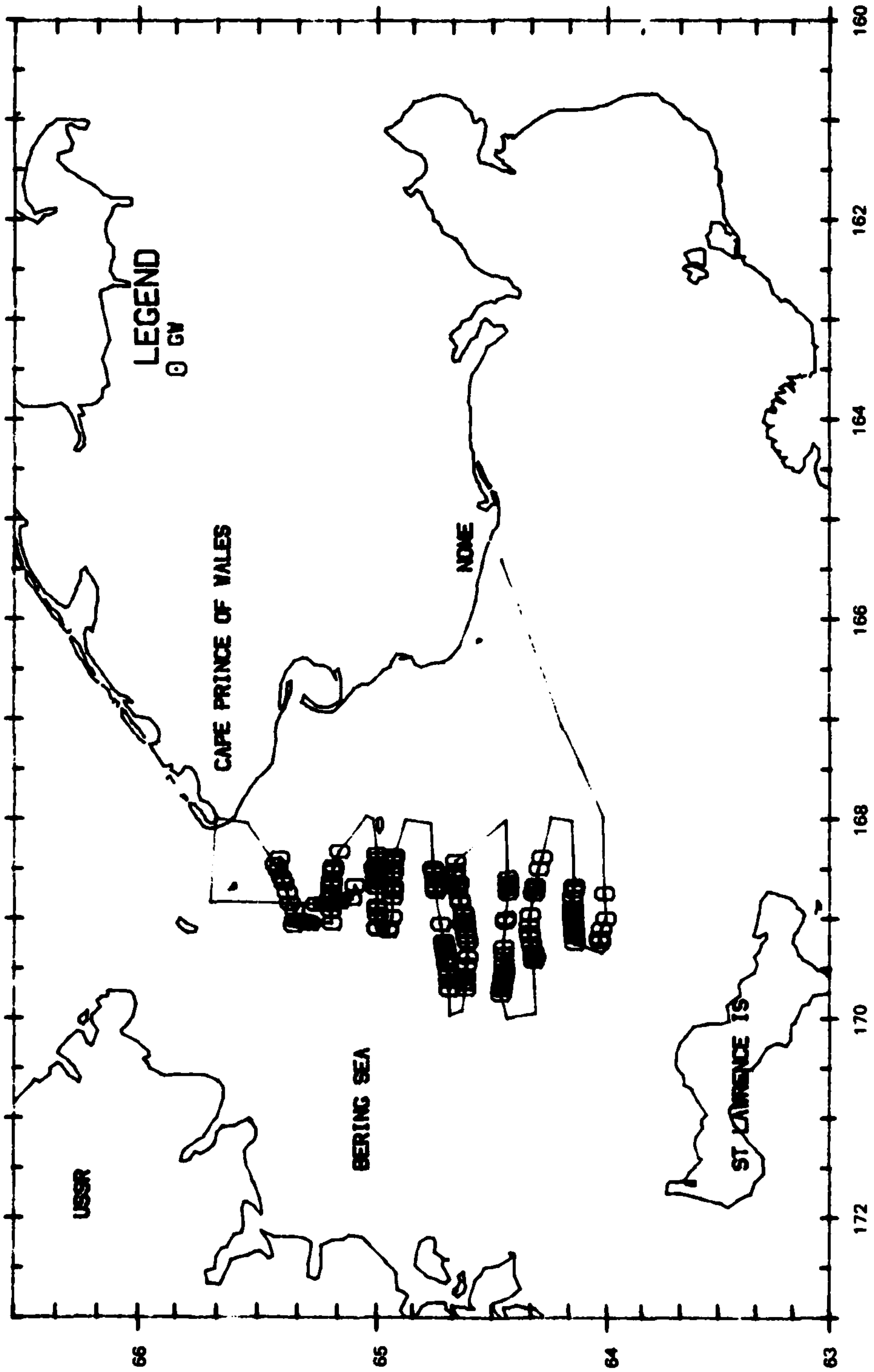
Flight 19: 22 July 1983

Flight was a transect survey of block C. Weather was clear and calm with generally unlimited visibility. Sea state was Beaufort 01 to 02. There were 310 gray whales sighted west of King Island and south of Bering Strait. One sonobuoy was dropped near gray whales and a few sounds were recorded.



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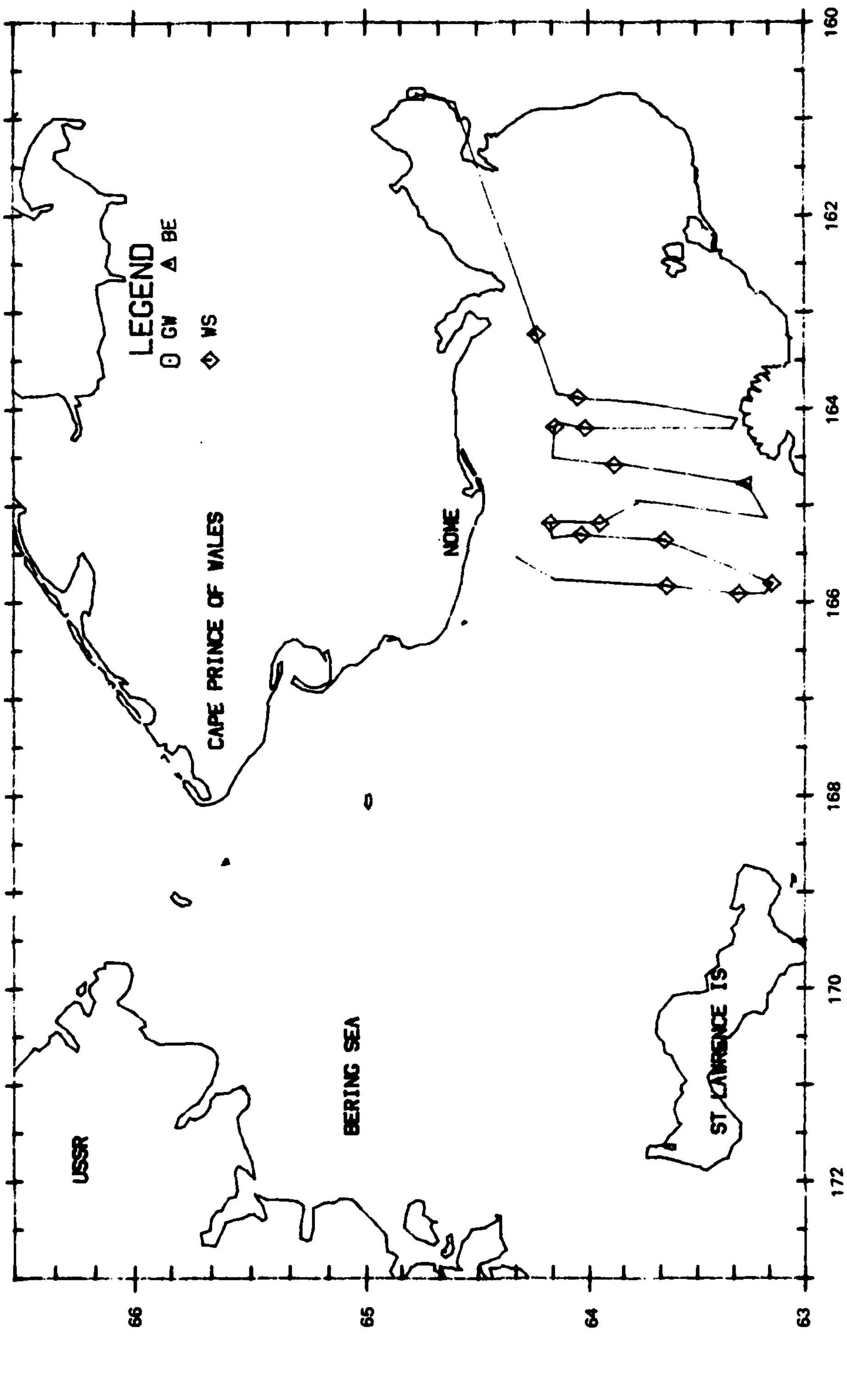
Flight 20: 23 July 1983

Flight was a transect survey of block A in Norton Sound. Weather was overcast with generally unlimited visibility. Sea state was Beaufort 02 to 03. One dead beached whale, probably a gray whale, belukhas, and dead walruses were seen. One sonobuoy was dropped near an inactive seismic boat but no sounds were recorded.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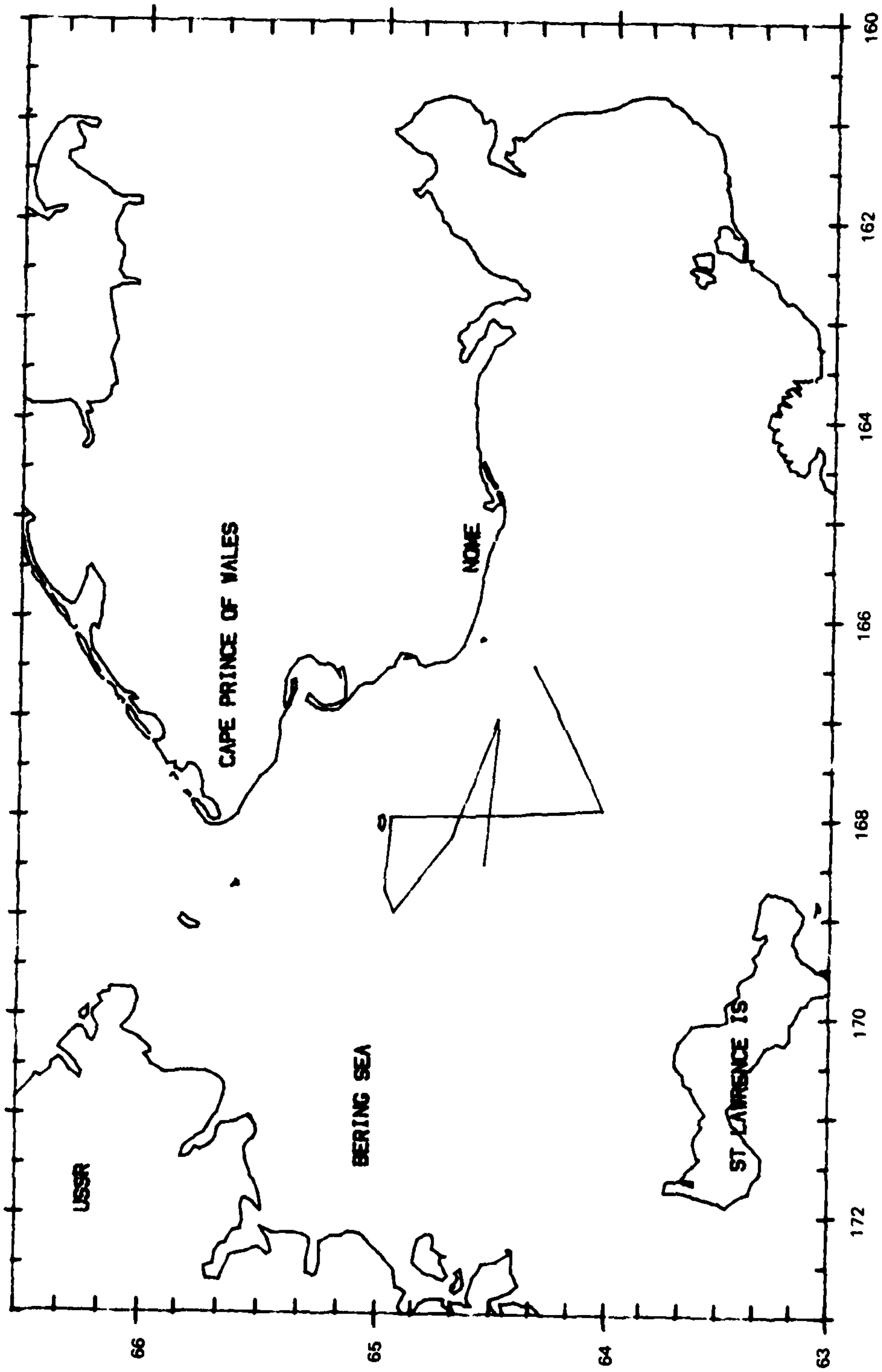
Flight 21: 28 July 1983

Flight was an attempted transect survey of block C that was aborted due to fog. Weather was low fog offshore with poor visibility. Sea state was Beaufort 01 to 03. No animals were seen.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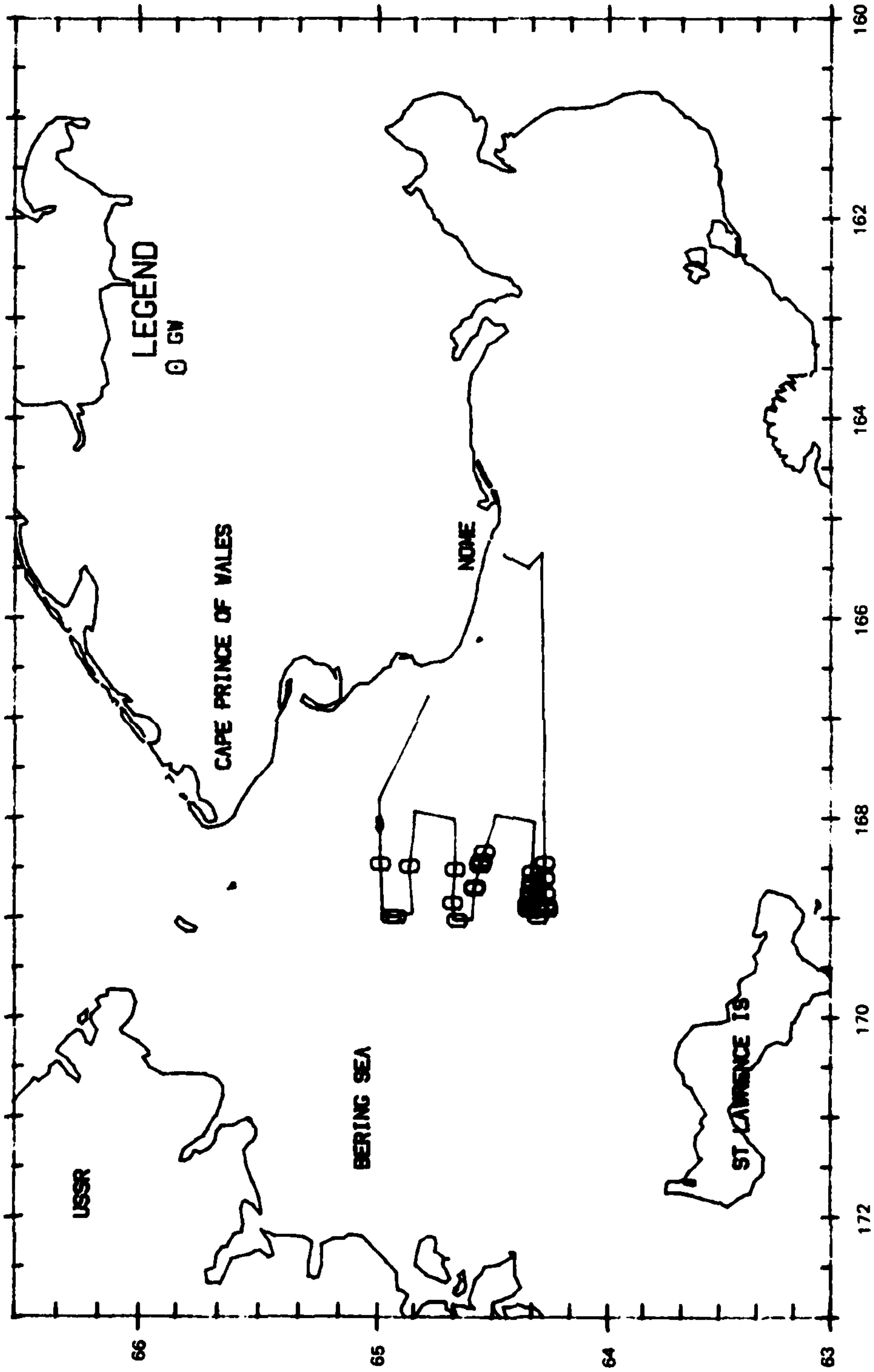
Flight 22: 29 July 1983

Flight was a search survey near King Island when a transect survey in block C was aborted due to fog. Weather was low fog offshore with poor visibility. Sea state was Beaufort 01 to 03. Forty nine gray whales were seen.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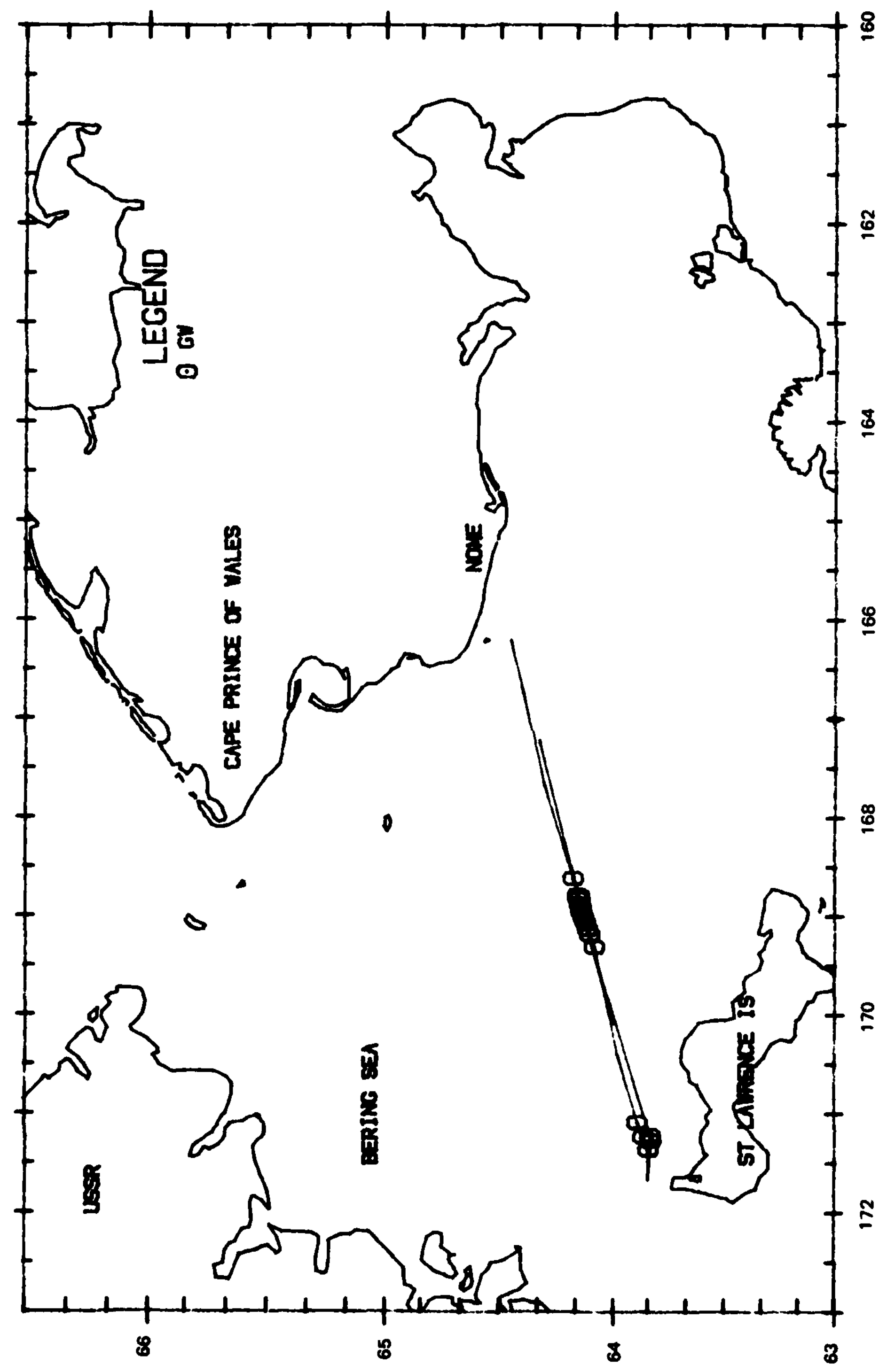
Flight 23: 30 July 1983

Flight was a search survey to St. Lawrence Island. Weather was patchy fog with generally 3 km visibility. Sea state was Beaufort 01 to 02. Forty-five gray whales were sighted between 168°W and 172°W near 64°N.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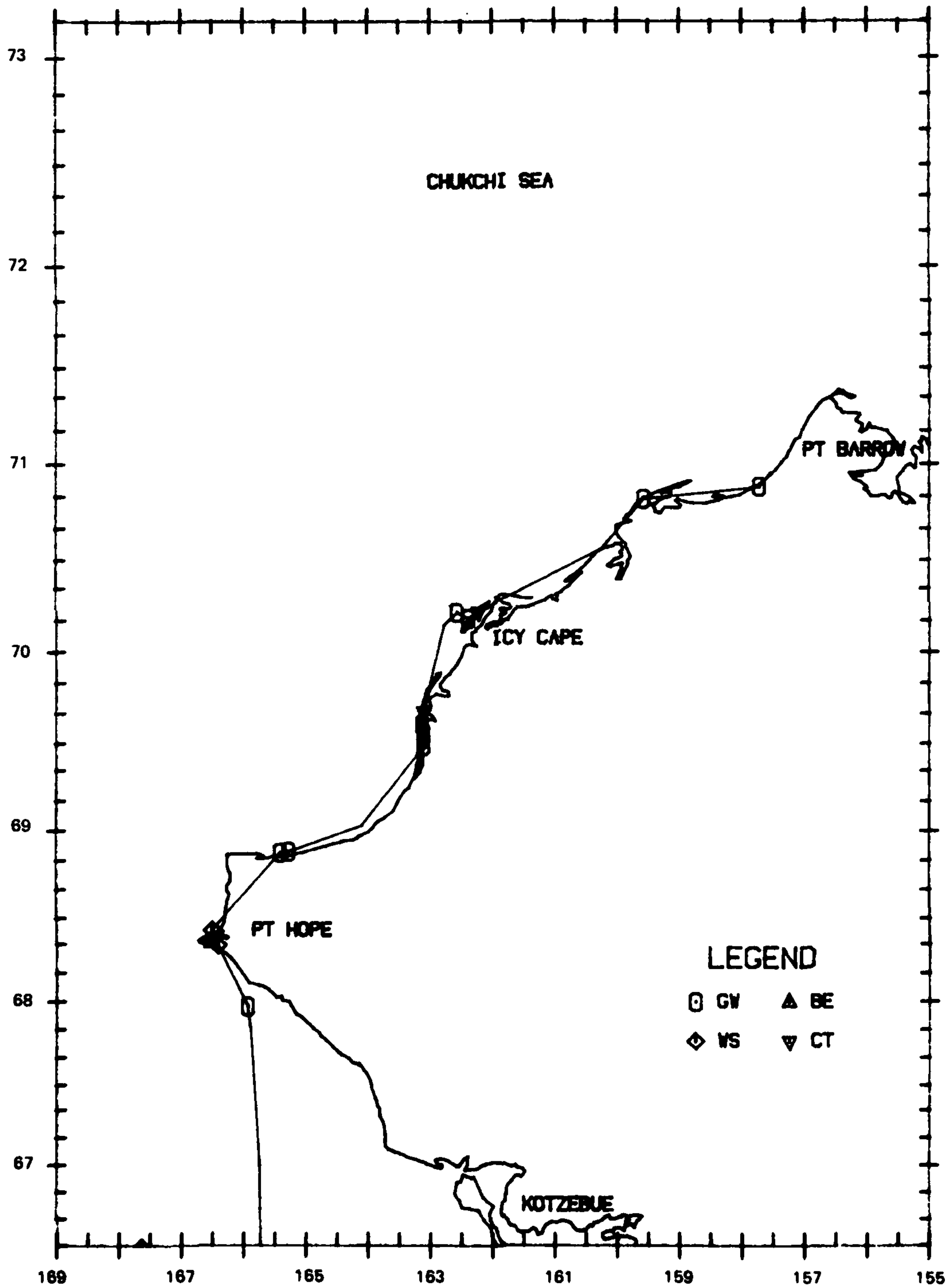
Flight 24: 31 July 1983

Flight was a coastal search survey from Nome to Pt. Barrow. Weather was generally clear with unlimited visibility. Ice coverage was over 9/10 beginning at Wainwright. Sea state was Beaufort 02. Twenty-one live gray whales and eight beached gray whale carcasses were sighted along the coast between Cape Prince of Wales and Pt. Barrow. A belukha, an unidentified cetacean, and walruses were also seen.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CHUKCHI SEA
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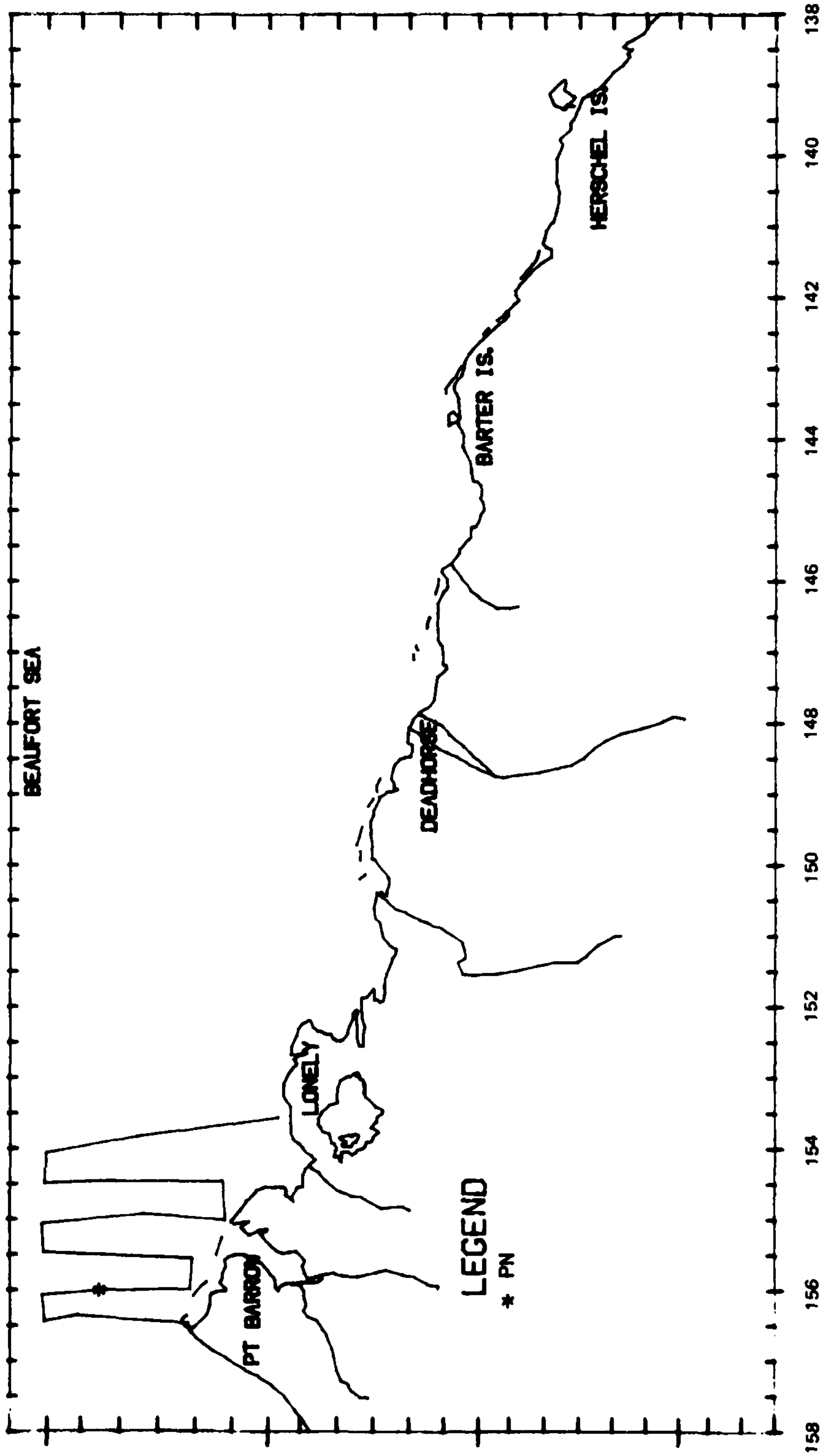
Flight 25: 31 July 1983

Flight was a transect survey of block 12. Weather ranged from clear with unlimited visibility to low overcast and fog, with less than 1 km visibility, over the northern half of the block. Ice coverage was 9/10 with sea state Beaufort 00 to 02. One unidentified pinniped was seen.


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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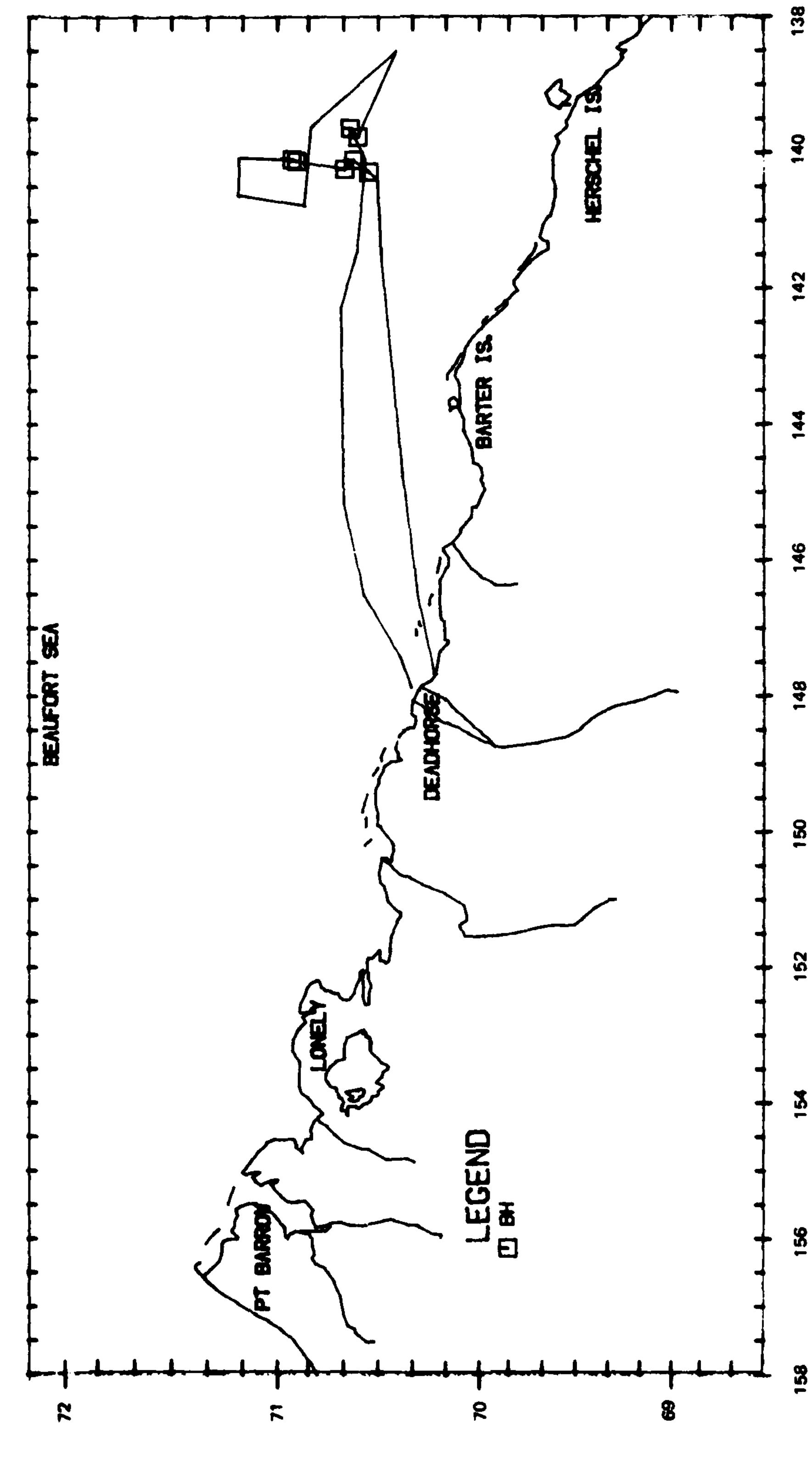
Flight 26: 2 August 1983

Flight was a search survey of block 7. Weather was low overcast and fog with less than 1 km of visibility except for a clear area in the eastern one-third of the block. Ice coverage was generally 9/10 with sea state Beaufort 00 to 04. Eight bowheads were seen northeast of Demarcation Bay in 9/10 broken floe ice. Whales exhibited various social behaviors. A sonobuoy was dropped and bowhead sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°32.6'	140°17.1'	-	BW	SH	-	4	B0	728
1/0	70°37.0'	140°06.4'	3206	BO	SH	-	4	B0	1283
1/0	70°39.6'	140°14.7'	1365	SP	BR	220	4	B0	1283
1/0	70°53.2'	140°00.7'	-	BO	SW	-	4	B0	2013
1/0	70°54.4'	140°06.4'	-	BW	SW	270	4	B0	2013
1/0	70°35.8'	139°46.3'	-	BW	RE	-	4	B0	915
2/0	70°38.0'	139°38.3'	-	BW	SW	270	4	B0	1217


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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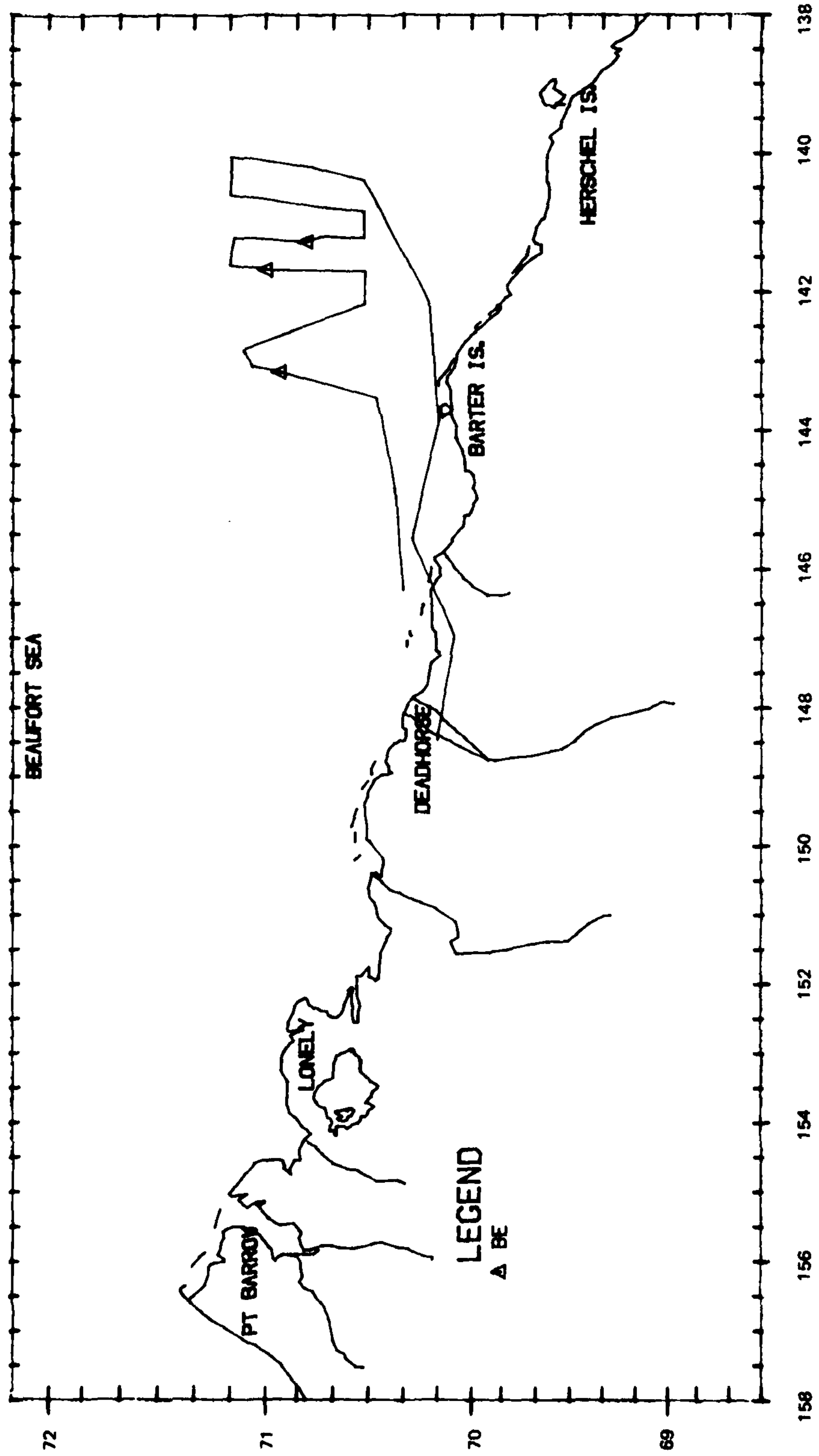
Flight 27: 3 August 1983

Flight was a transect survey of block 7. Weather was variable from overcast with unlimited visibility to fog with less than 1 km visibility in the northern third of the block. Ice coverage was 1/10 at the southeast corner of block, otherwise 9/10; sea state ranged from Beaufort 01 to 02. Belukhas were seen, including one cow-calf pair.


BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
LONELY
PT BARROW
LEGEND
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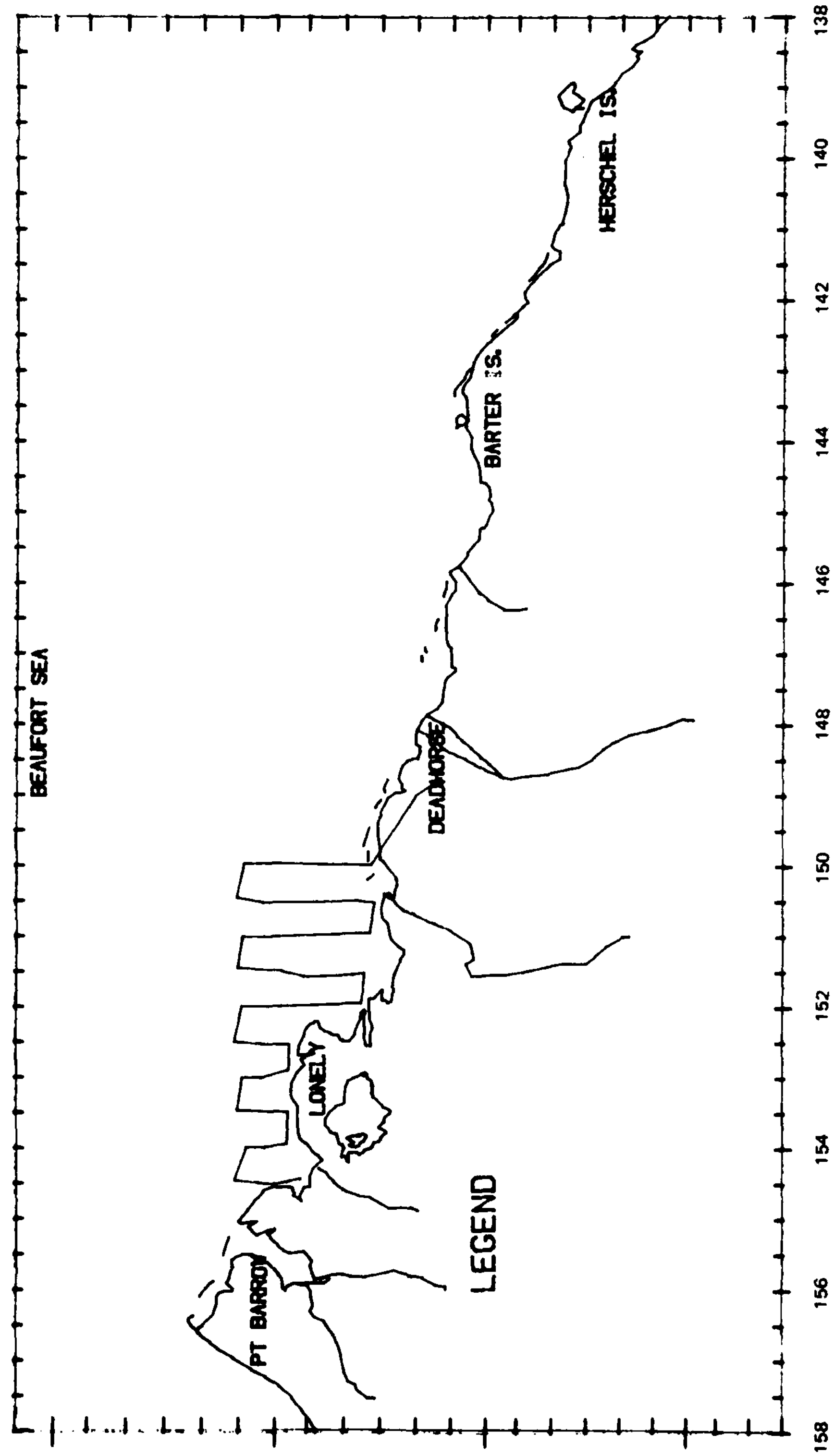
Flight 28: 4 August 1983

Flight was a transect survey of block 3. Weather varied from partly cloudy with up to 10 km visibility to fog and unacceptable visibility. Ice coverage was generally 9/10. Sea state was Beaufort 02. No animals were seen.


BEAUFORT SEA
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BARTER IS.
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AD-A146 373 AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING EASTERN CHUKCHI..(U) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA D K LJUNGBLAD ET AL. JUN 84 NOSC/TR-955

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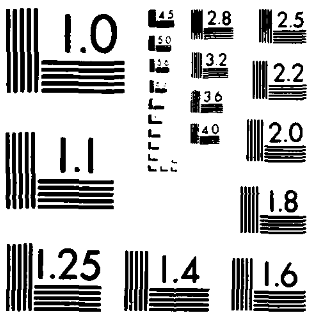
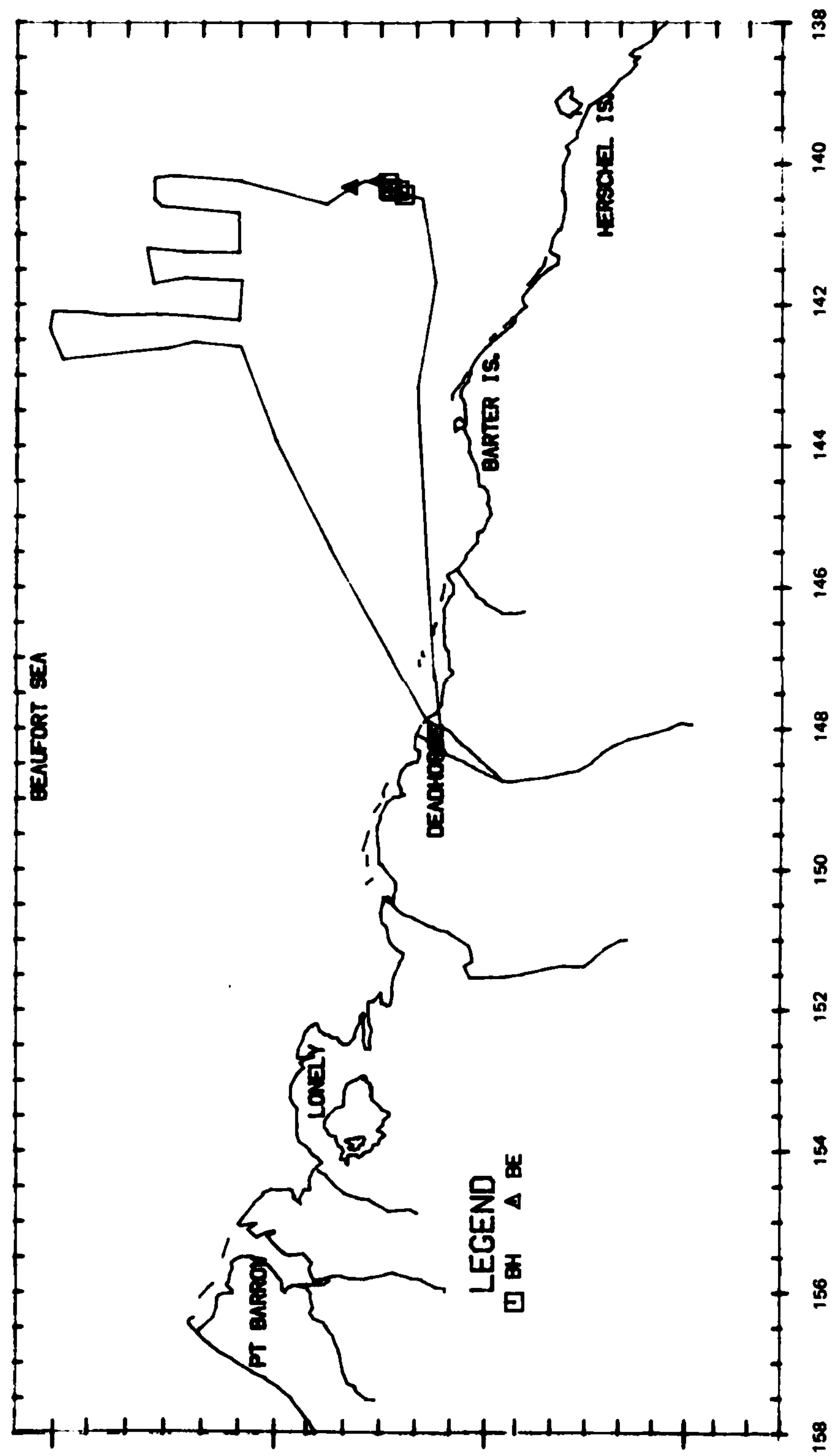


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Flight 29: 5 August 1983

Flight was a transect survey of block 8 and a search survey of blocks 5 and 7. Weather was low overcast with fog. Visibility ranged from unlimited to unacceptable. Ice coverage was 9/10 and sea state Beaufort 00 to 01. Twenty-one bowheads exibiting social behavior were seen north of Demarcation Bay. Belukhas were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
4/0	70°27.7'	140°16.1'	873	BW	RE	-	3	B2	458
5/0	70°27.0'	140°23.2'	2074	BO	SW	060	3	B2	458
3/0	70°27.0'	140°21.1'	-	BW	RE	-	3	B2	458
3/0	70°27.6'	140°21.3'	-	BW	UB	-	3	B2	458
1/0	70°24.7'	140°22.3'	-	BO	SW	210	3	B2	439
5/0	70°23.1'	140°26.5'	-	BO	SW	-	3	B2	439


BEAUFORT SEA
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BARTER IS.
HERSCHEL IS.
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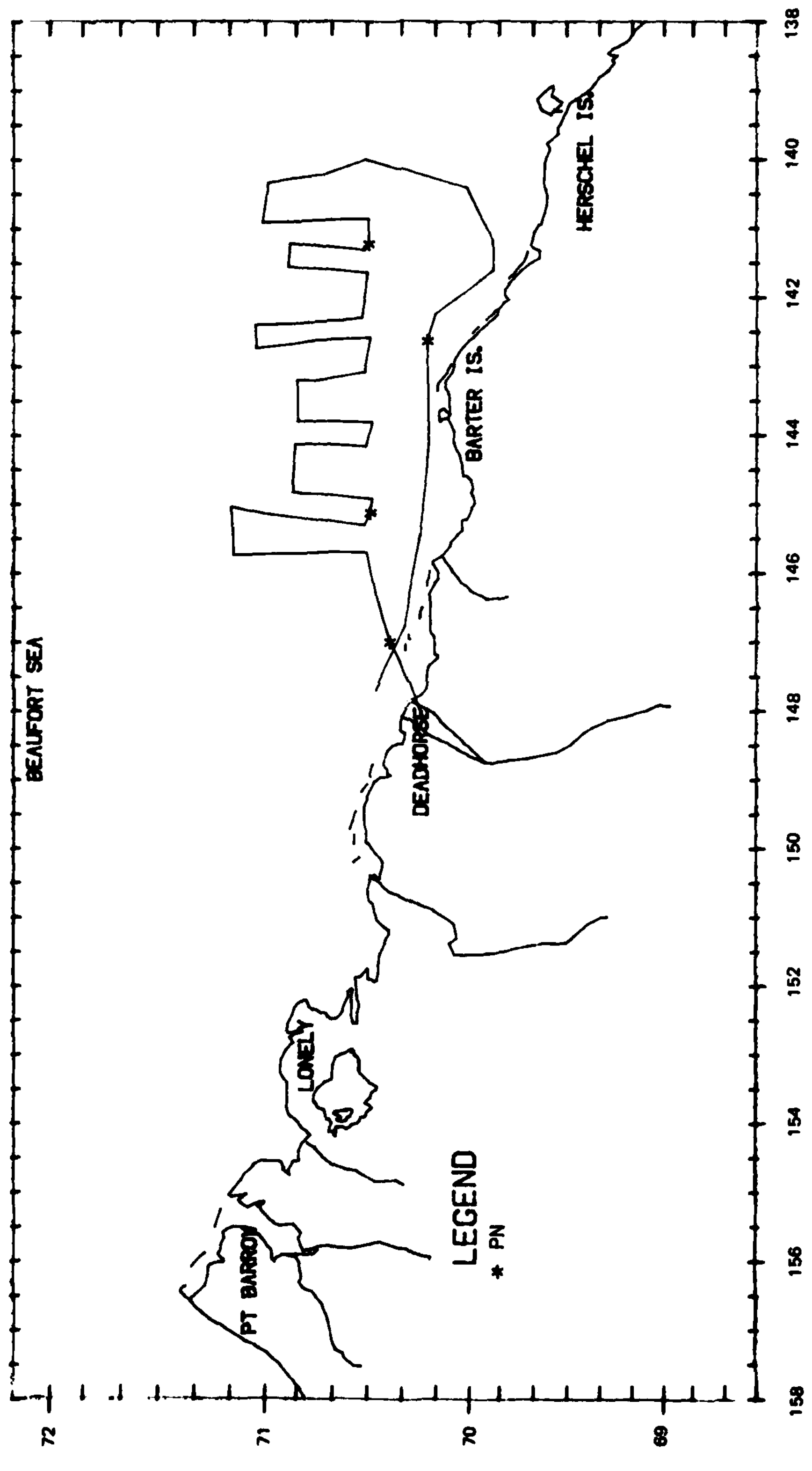
Flight 30: 8 August 1983

Flight was a transect survey of blocks 6 and 7. Weather ranged from fog to low overcast. Visibility ranged from unlimited to unacceptable and caused some transect legs to be truncated. Ice coverage was 9/10, with sea state Beaufort 00 to 01. Unidentified pinnipeds were seen.


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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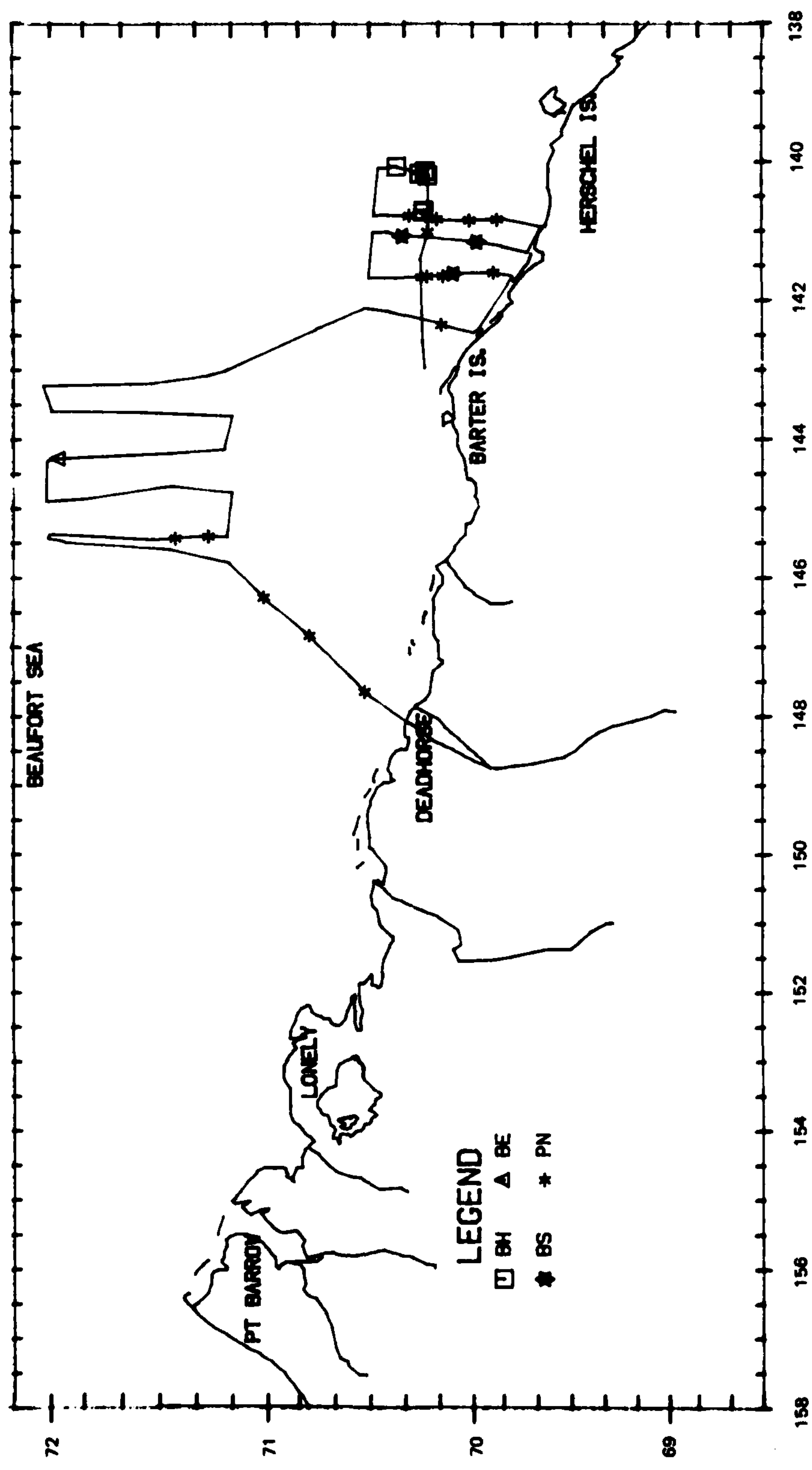
Flight 31: 9 August 1983

Flight was a transect survey of blocks 9 and 5. Weather was low overcast with fog. Visibility ranged from unlimited to unacceptable. Ice coverage was 9/10 except the southeast corner of block 5 which had open water. Sea state was Beaufort 00 to 02. Fifteen bowheads, including one calf, were seen along the ice edge north of Demarcation Bay. Swimming and feeding were the predominant behaviors. Belukhas, bearded seals, and unidentified pinnipeds were also seen. One sonobuoy was dropped and seismic and a few bowhead sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°14.0'	140°44.2'	-	BW	SW	240	0	B1	55
1/0	70°14.1'	140°44.7'	-	BO	SW	210	0	B1	48
4/0	70°14.0'	140°43.7'	-	BO	SW	-	0	B1	55
1/0	70°21.8'	140°05.2'	188	BO	SW	060	0	B2	82
3/0	70°15.1'	140°11.6'	473	BW	SW	150	0	B2	62
1/0	70°13.5'	140°09.6'	-	BO	UB	150	0	B2	62
4/1	70°12.7'	140°13.5'	-	BO	FE	-	0	B2	62


BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
LONELY
PT BARROW
LEGEND
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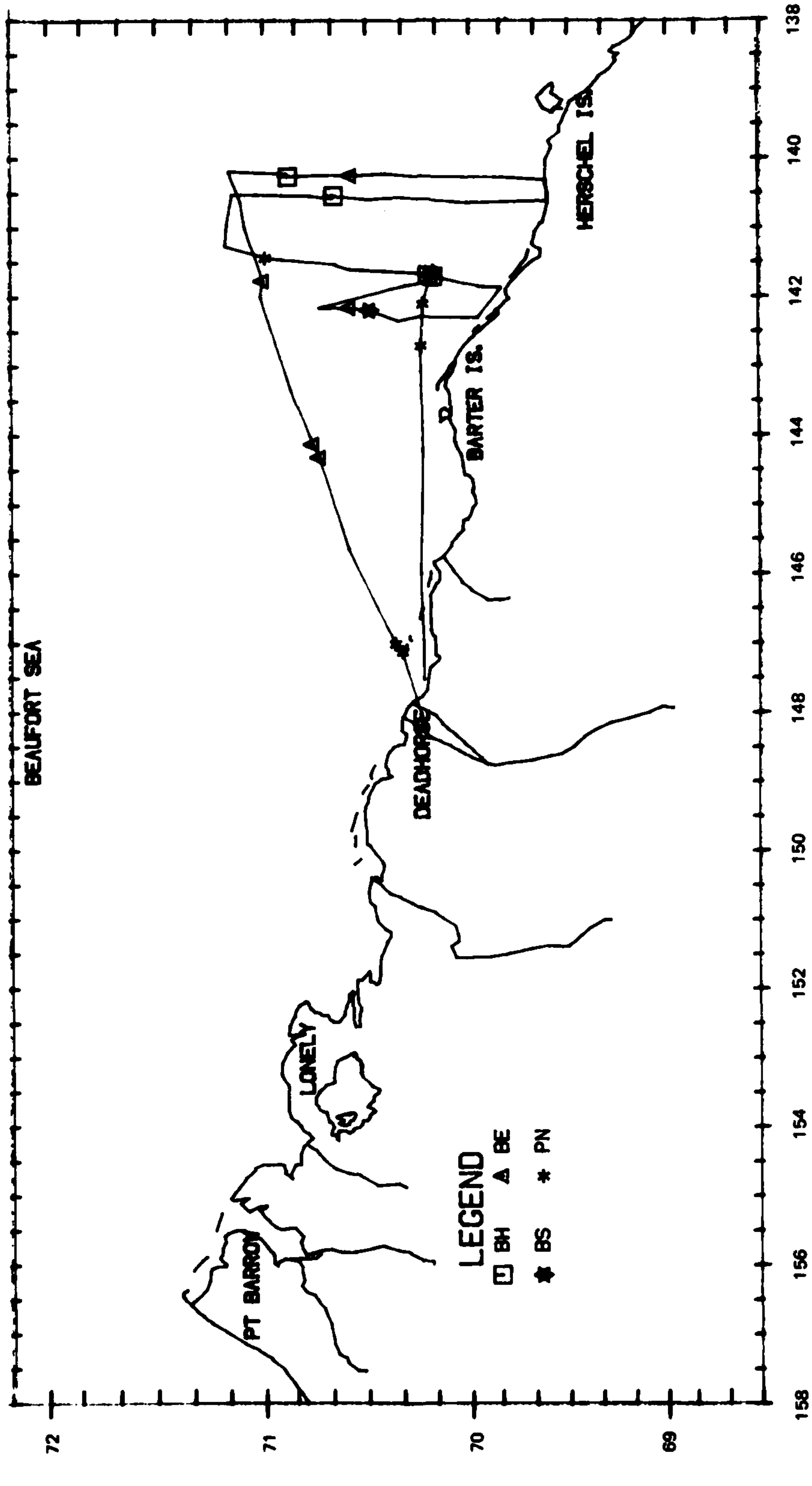
Flight 32: 10 August 1983

Flight was a partial transect survey of blocks 5 and 7. Weather was overcast and visibility unlimited. Ice coverage was 9/10 in block 7 with open water in block 5. Sea state was Beaufort 01 to 03. Five bowheads, including one calf, were seen along the ice edge north of Demarcation Bay. Most were swimming. Belukhas, a bearded seal, and unidentified pinnipeds were also seen. One sonobuoy was dropped and seismic sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°51.9'	140°17.0'	457	SP	UB	330	4	B1	1887
1/0	70°51.9'	140°17.0'	-	BO	SW	270	4	B1	1887
1/0	70°39.3'	140°33.7'	-	BO	SW	030	9	B1	1244
1/0	70°12.3'	141°42.6'	1434	SP	DI	240	0	B2	55
1/1	70°10.9'	141°43.7'	-	BO	DI	-	0	B2	55



BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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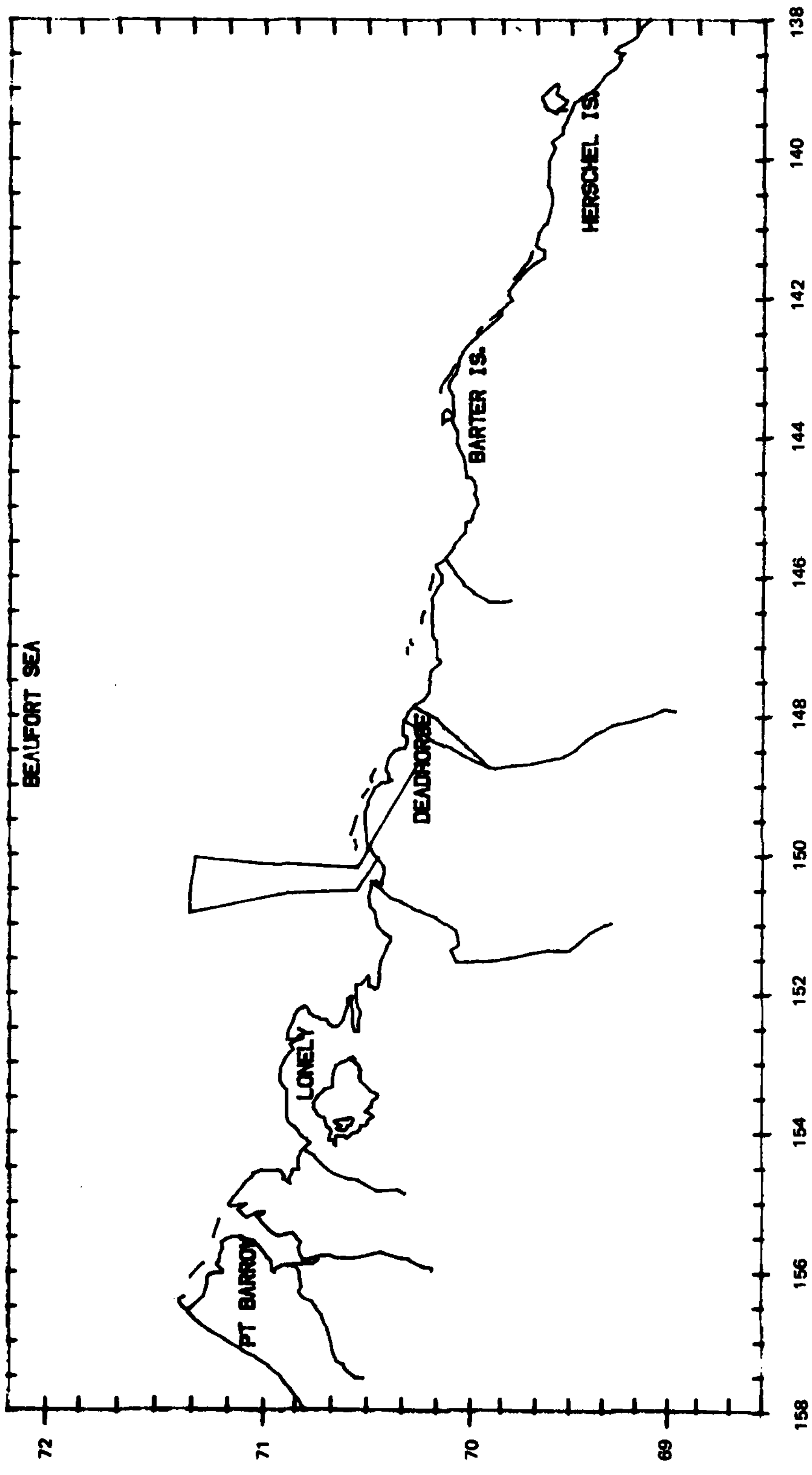
Flight 33: 15 August 1983

Flight was a search survey of block 3. Weather was low fog over the entire block. Visibility ranged from 1 to 2 km to unacceptable. Ice coverage was 9/10 in the northern half of the block with open water nearshore. Sea state was Beaufort 01 to 02. No bowheads or other animals were seen. Flight was aborted after the second leg due to restricted visibility.


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
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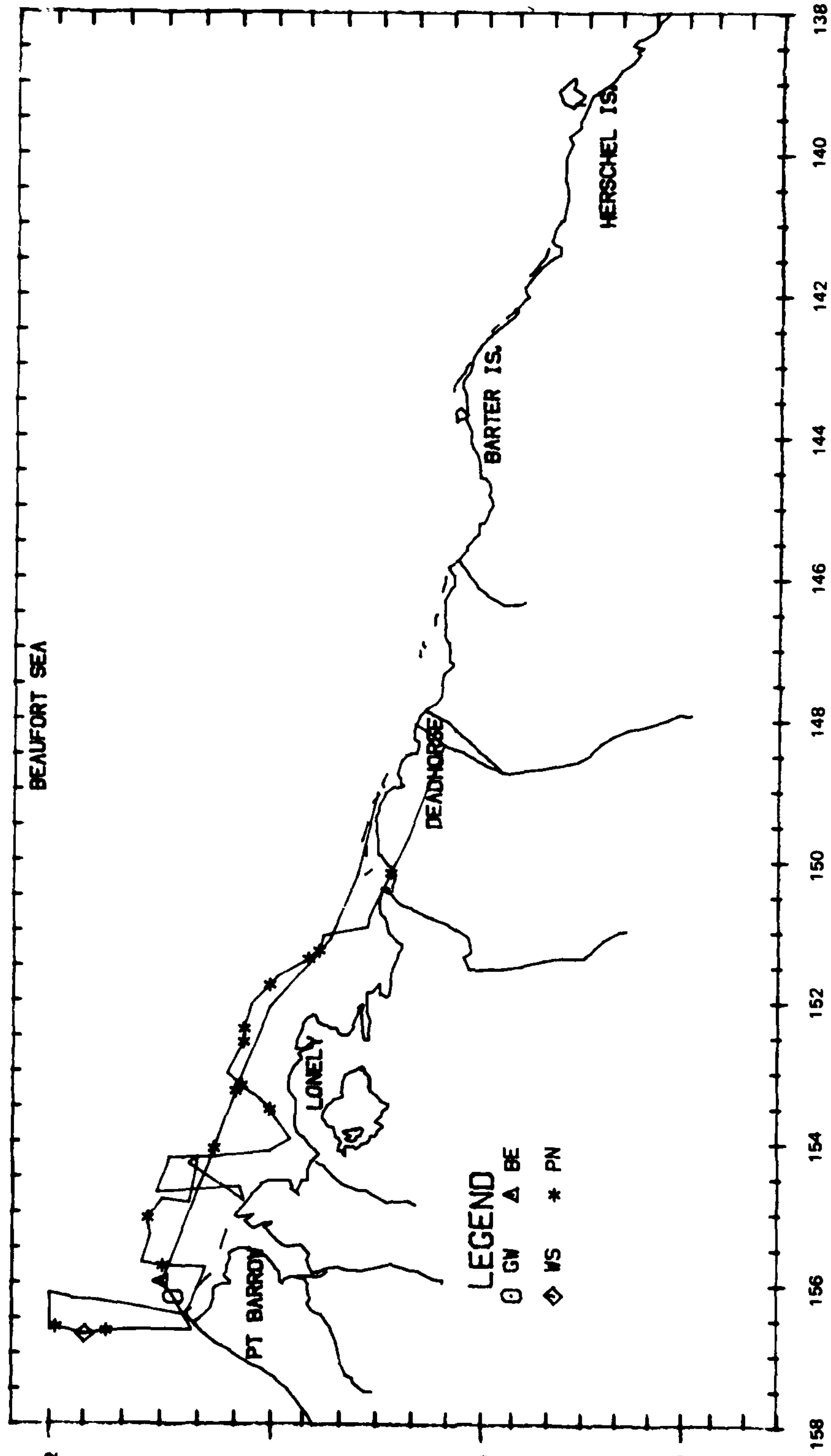
Flight 34: 17 August 1983

Flight was a transect survey of block 12. Weather was clear with visibility unlimited in the southern half of the block; heavy fog with unacceptable visibility in the northern half caused transect legs to be truncated. Ice coverage was generally 1/10 with some 9/10 coverage at the northern extreme of the legs. Sea state was Beaufort 00 to 02. Thirteen gray whales, including one calf, were seen north of Pt. Barrow. Belukhas, walruses and unidentified pinnipeds were also seen.


BEAUFORT SEA
HERSCHEL IS.
BARTER IS.
DEADHORSE
LONELY
PT BARROW
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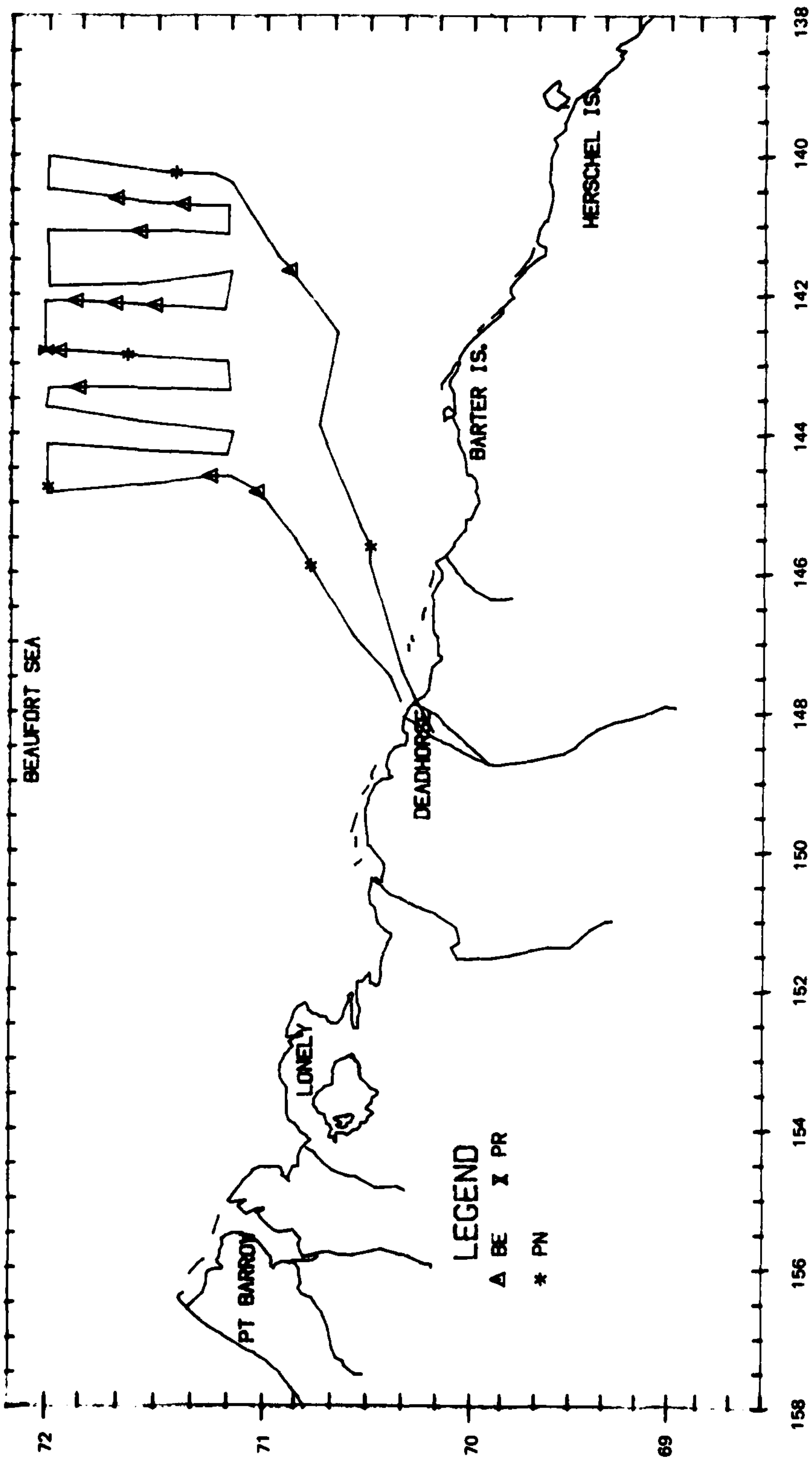
Flight 35: 18 August 1983

Flight was a transect survey of blocks 8 and 9. Weather was clear with unlimited visibility. Ice coverage was 9/10 broken floe with sea state Beaufort 00 to 01. Polar bears, belukhas and unidentified pinnipeds were seen.



BEAUFORT SEA
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BARTER IS.
HERSCHEL IS.
LONELY
PT BARROW
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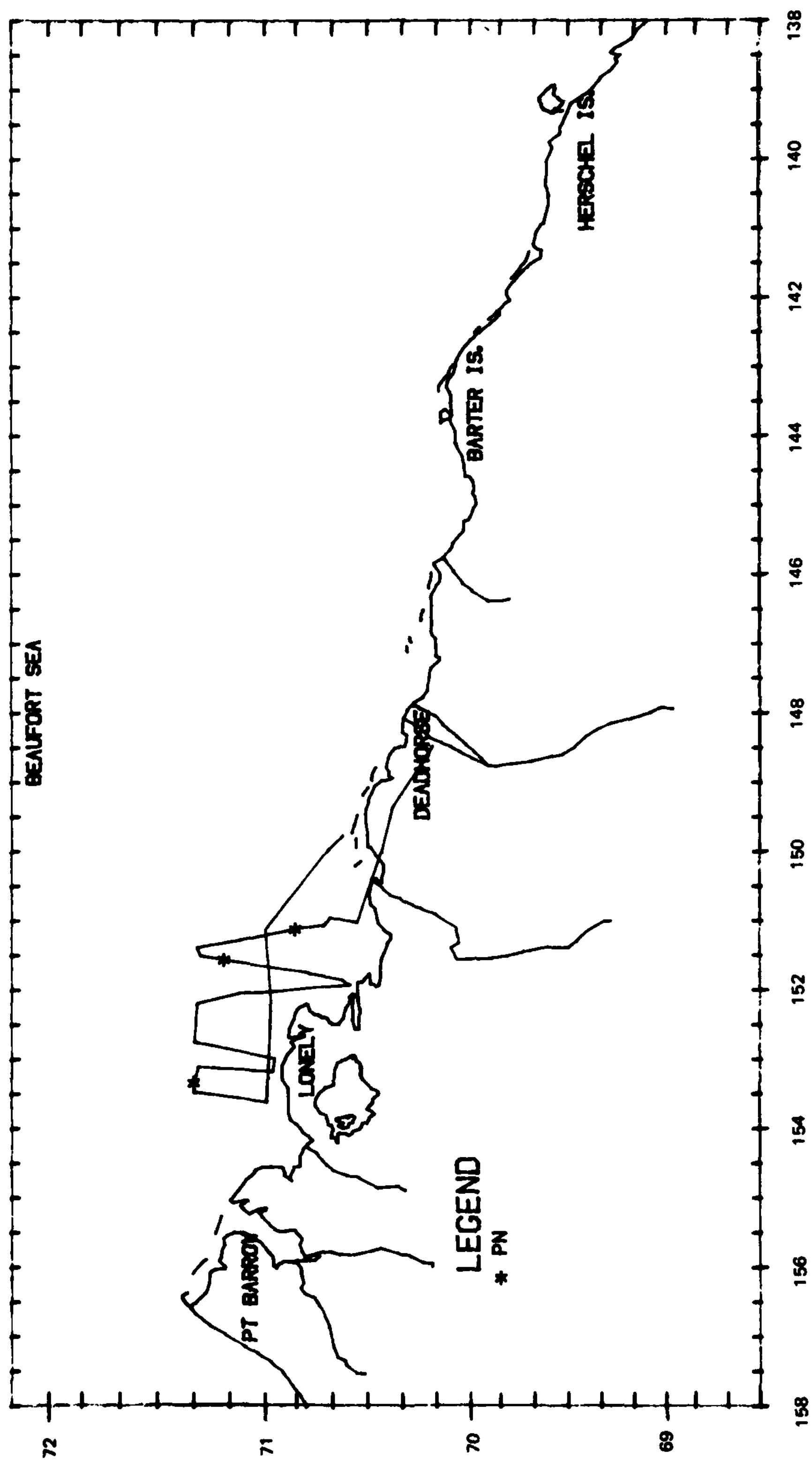
Flight 36: 19 August 1983

Flight was a transect survey of block 3. Weather was low overcast and windy with generally 7 km visibility. Ice coverage ranged from open water to 9/10 broken floe. Sea state was Beaufort 01 to 02. Unidentified pinnipeds were seen.



BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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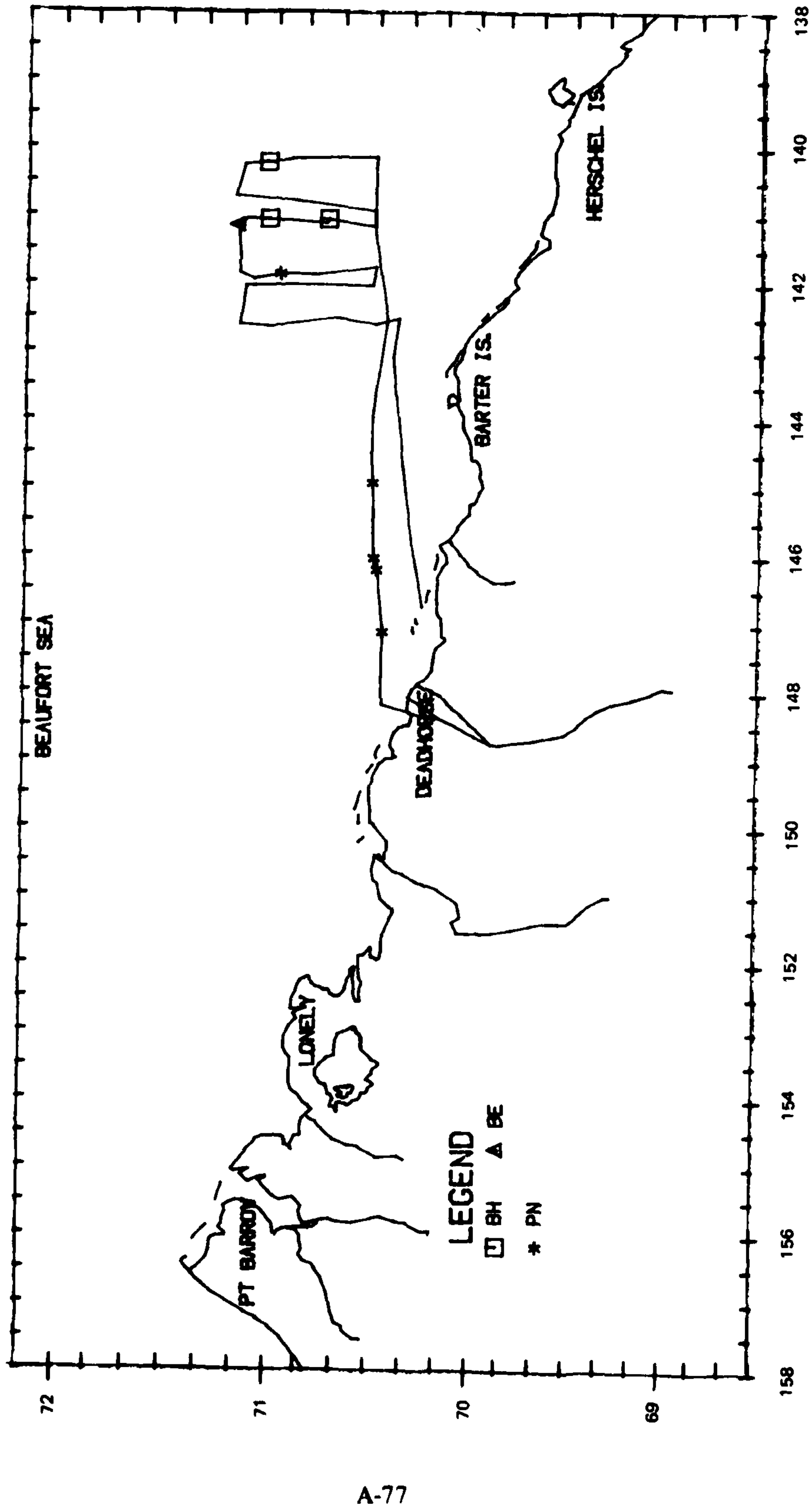
Flight 37: 20 August 1983

Flight was a transect survey of block 7. Weather varied from clear with unlimited visibility over open water and sea state of Beaufort 04, to fog with unacceptable visibility over 9/10 broken floe ice and sea state Beaufort 01. Five bowheads were seen swimming various directions. A belukha and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°02.8'	140°13.0'	-	BO	SW	150	1	B4	2196
3/0	70°44.2'	141°03.5'	-	BW	SW	270	0	B3	1647
1/0	71°02.3'	141°03.1'	-	BW	SW	060	0	B3	2379


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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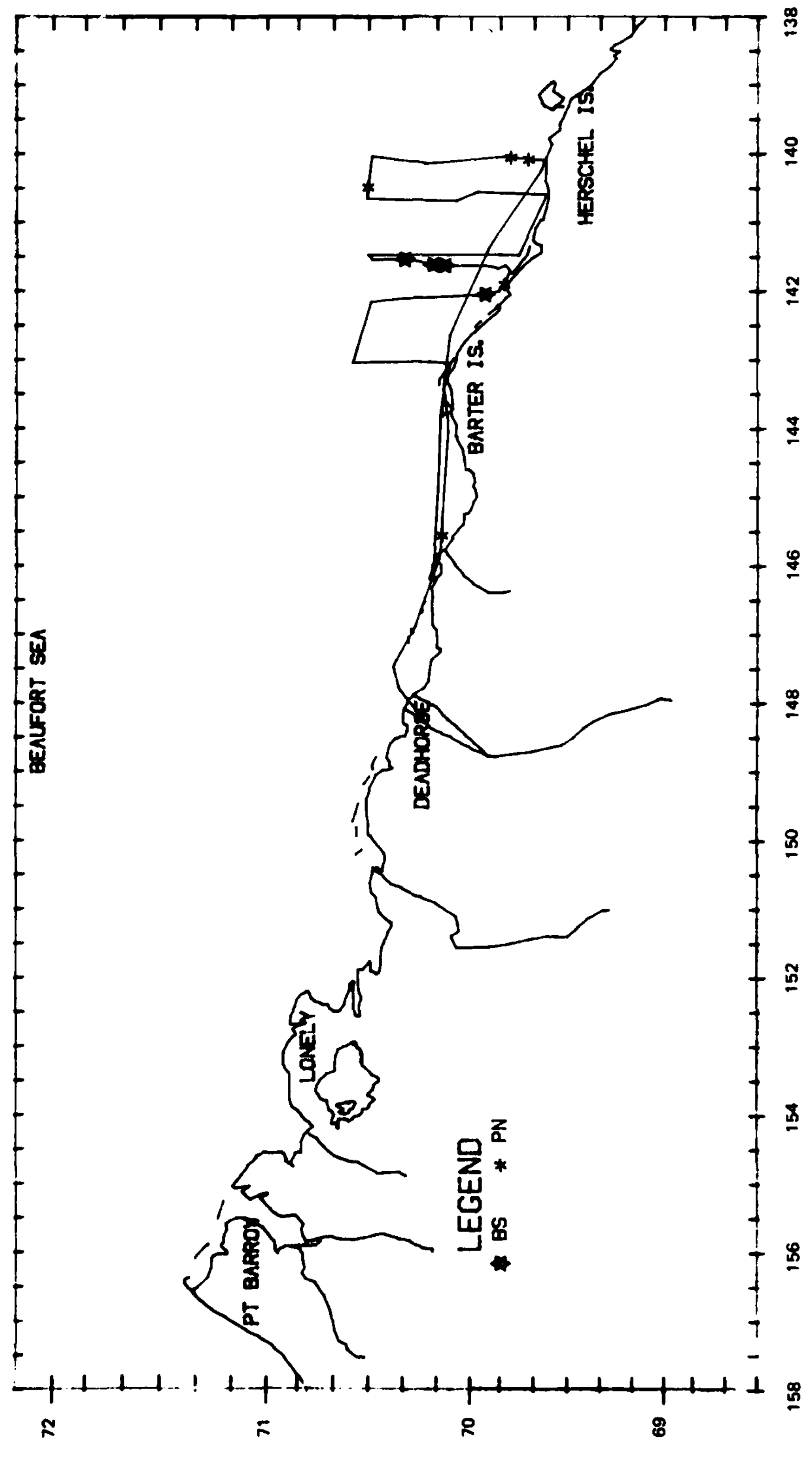
Flight 38: 21 August 1983

Flight was a transect survey of block 5. Weather was clear with unlimited visibility. The water was ice free and sea state Beaufort 02. Bearded seals and unidentified pinnipeds were seen.


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
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Flight 39: 23 August 1983

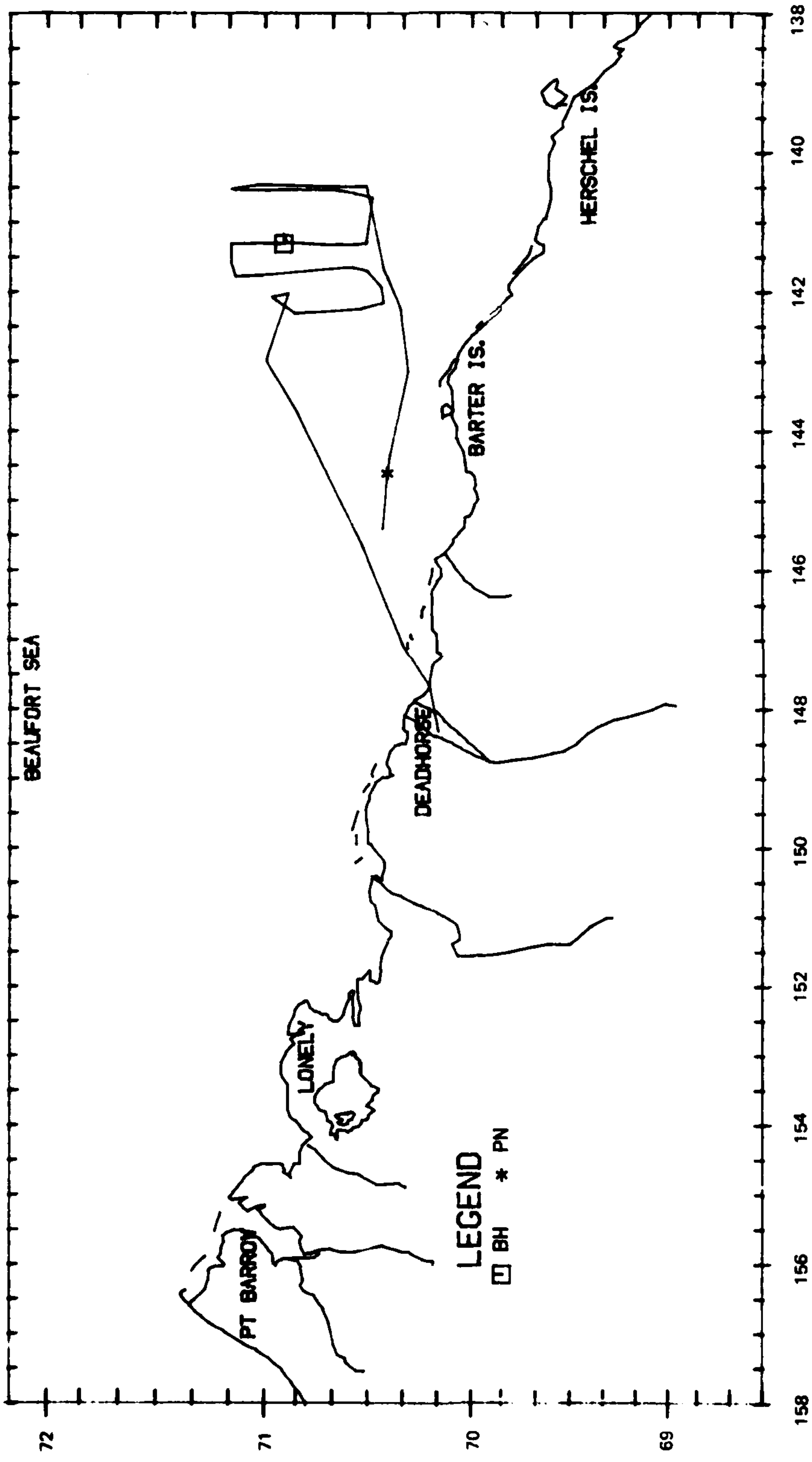
Flight was a transect survey of block 7. Weather was low overcast with patchy fog. Visibility was 3 to 5 km. There were patches of 1/10 broken floe ice. Sea state was Beaufort 03. One bowhead and one unidentified pinniped were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°54.0'	141°18.4'	3374	BW	SW	-	0	B3	1922

Flight 39: 23 August 1983

Flight was a transect survey of block 7. Weather was low overcast with patchy fog. Visibility was 3 to 5 km. There were patches of 1/10 broken floe ice. Sea state was Beaufort 03. One bowhead and one unidentified pinniped were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°54.0'	141°18.4'	3374	BW	SW	-	0	B3	1922



BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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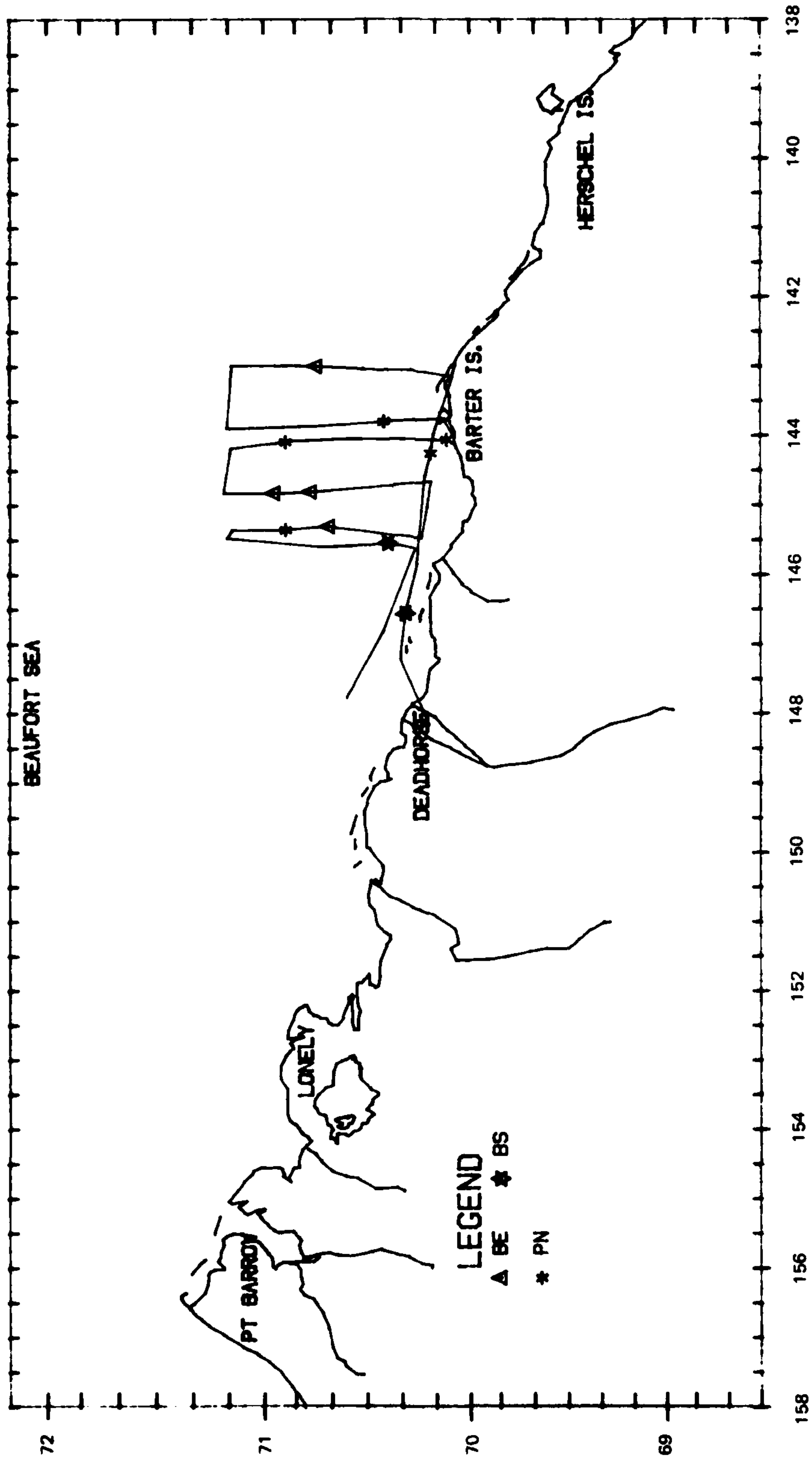
Flight 40: 24 August 1983

Flight was a transect survey of blocks 4 and 6. Weather was patchy fog with visibility 1 to 10 km. Ice coverage ranged from open water to 9/10 broken floe ice with sea state Beaufort 01. Cow-calf belukha pairs, bearded seals, and unidentified pinnipeds were seen.


BEAUFORT SEA
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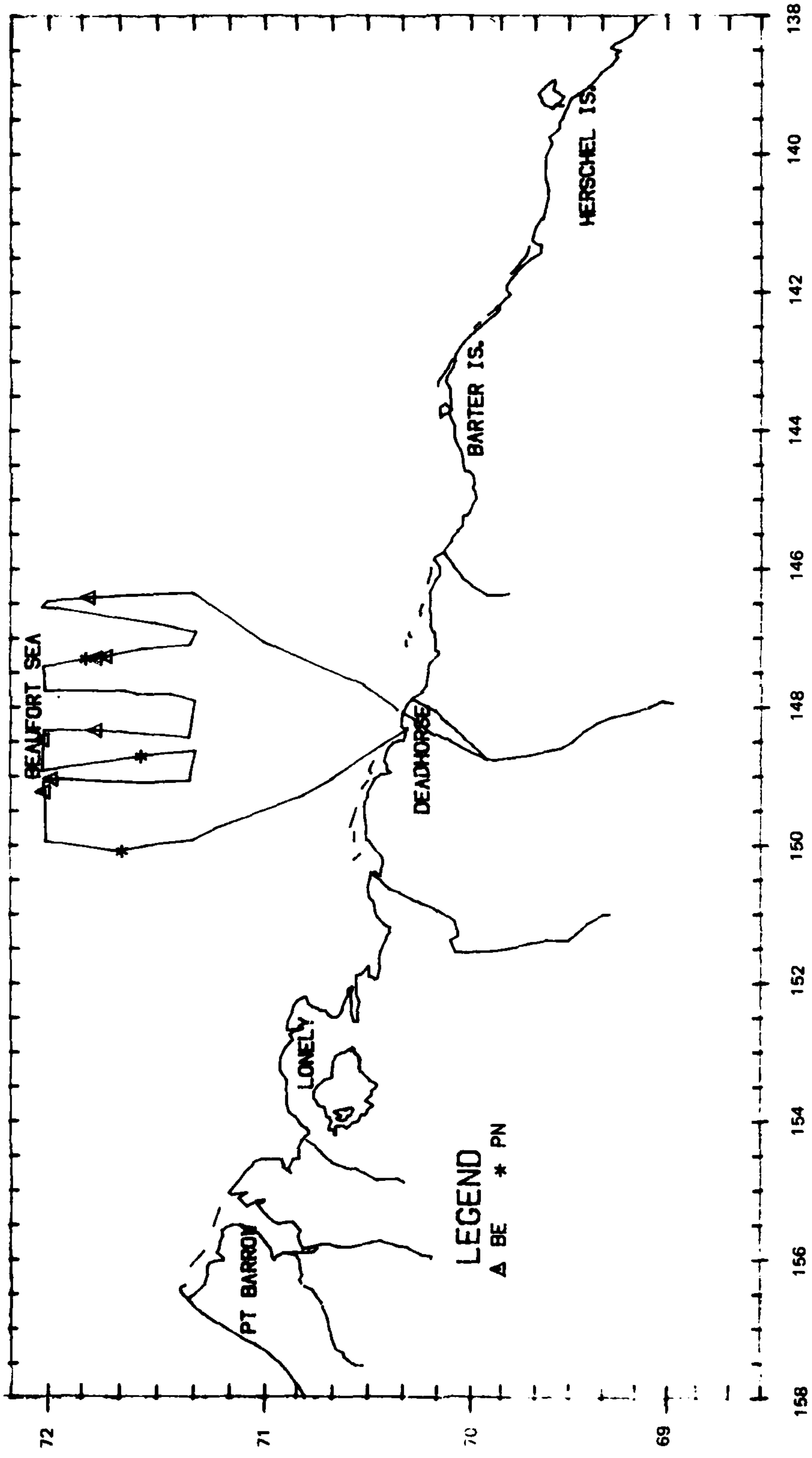
Flight 41: 25 August 1983

Flight was a transect survey of block 10. Weather was low overcast with fog. Visibility was 3 to 5 km. Ice coverage was 9/10 broken floe with sea state Beaufort 00. Belukhas and unidentified pinnipeds were seen. One sonobuoy was dropped and belukha sounds were recorded.


BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
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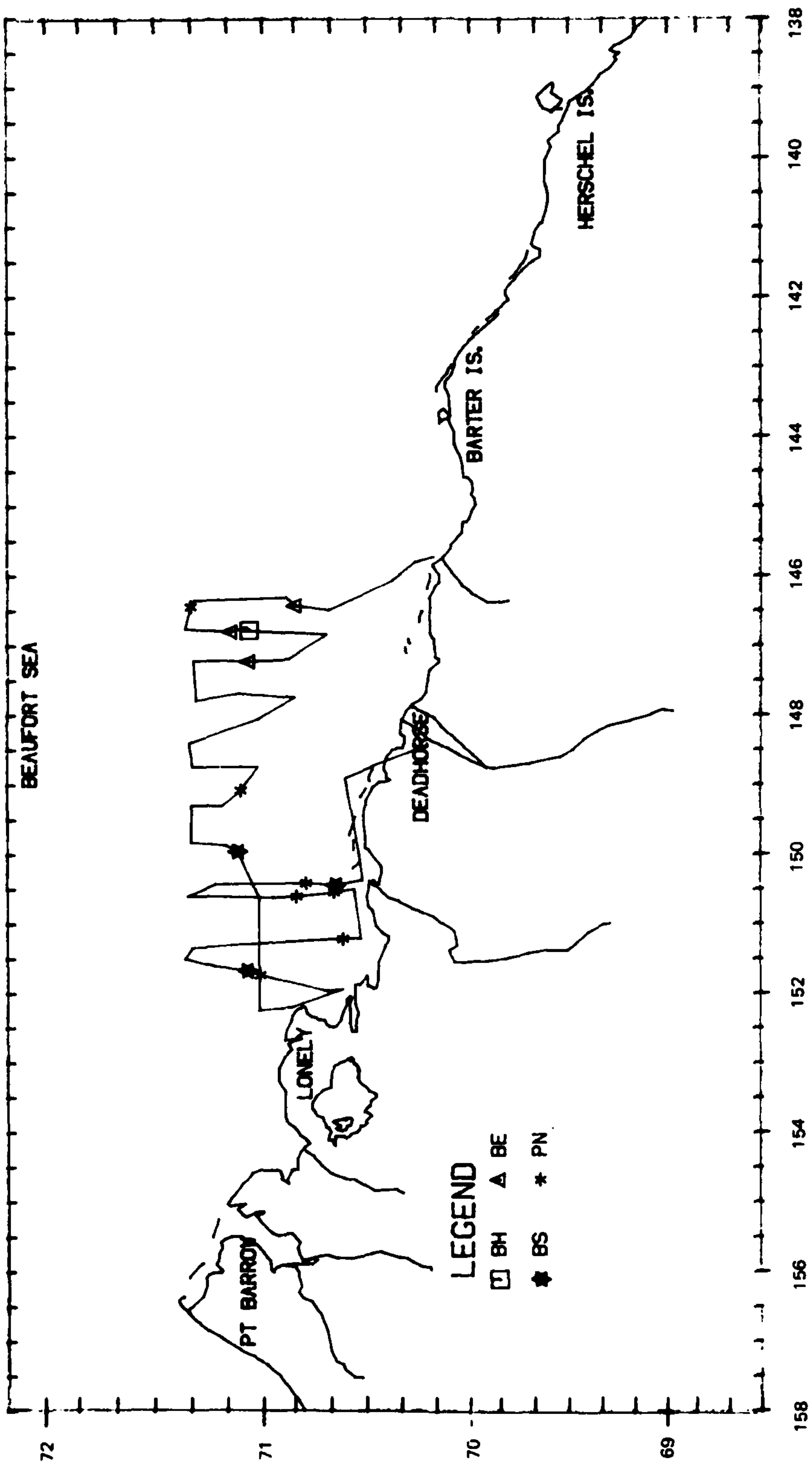
Flight 42: 26 August 1983

Flight was a transect survey of blocks 3 and 2. Weather was cloudy with unlimited visibility. Ice coverage was 9/10 broken floe with some new ice. Sea state was Beaufort 01. One bowhead, belukhas, bearded seals, and unidentified pinnipeds were seen. One sonobuoy was dropped, but no sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°02.9'	146°48.2'	-	BO	SW	180	9	B1	549


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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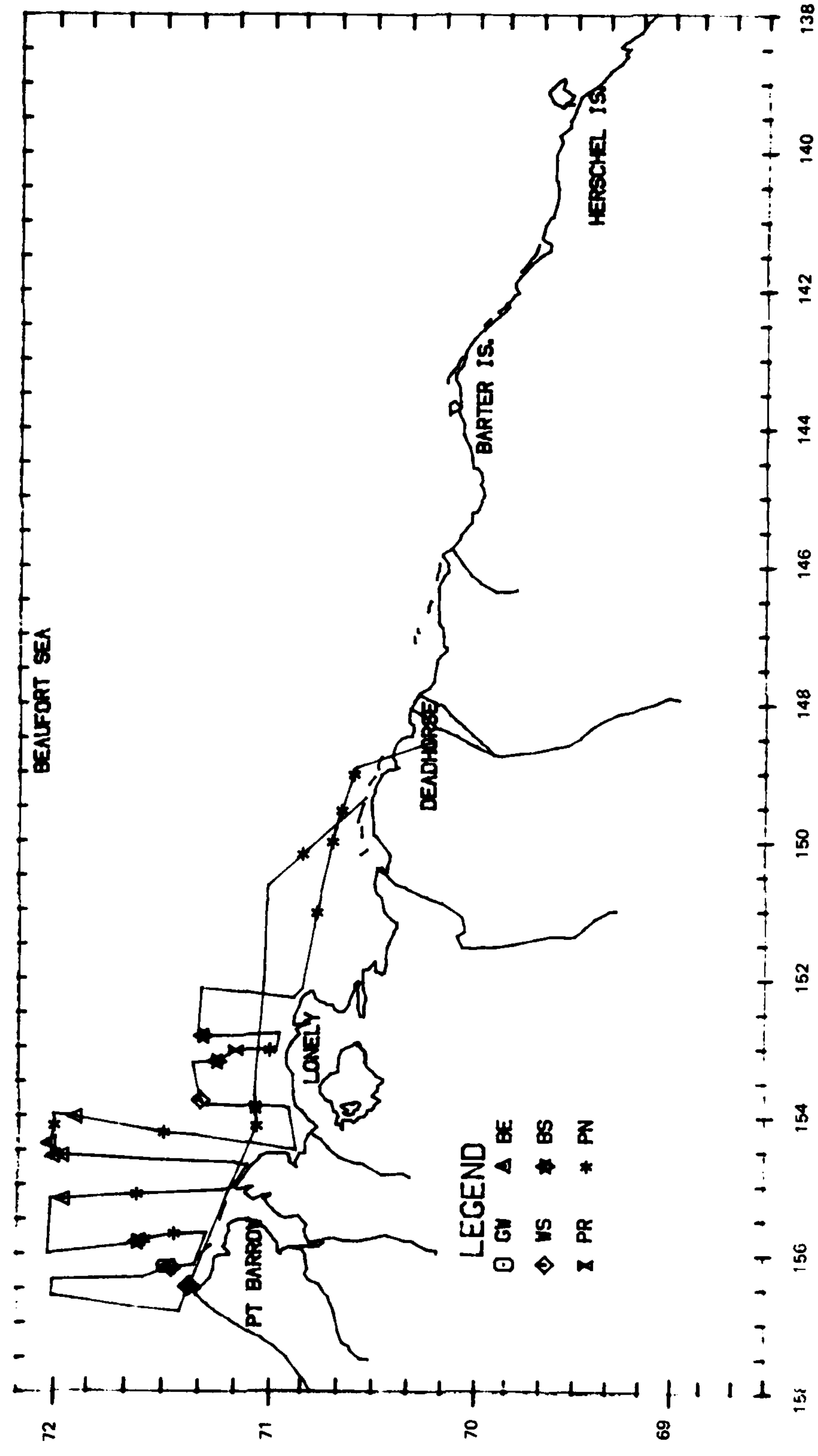
Flight 43: 27 August 1983

Flight was a transect survey of blocks 3 and 12. Weather was generally overcast with unlimited visibility. There was some fog in the northern extremes of the blocks resulting in unacceptable visibility. Ice coverage varied from open water nearshore to 9/10 broken floe north of 71°N. Sea state varied with the ice from Beaufort 03 in open water to Beaufort 01 in heavy ice coverage. A gray whale was seen north of Pt. Barrow. Belukhas, bearded seals, unidentified pinnipeds, walruses, and a polar bear were also seen.


BEAUFORT SEA
DEADHORSE
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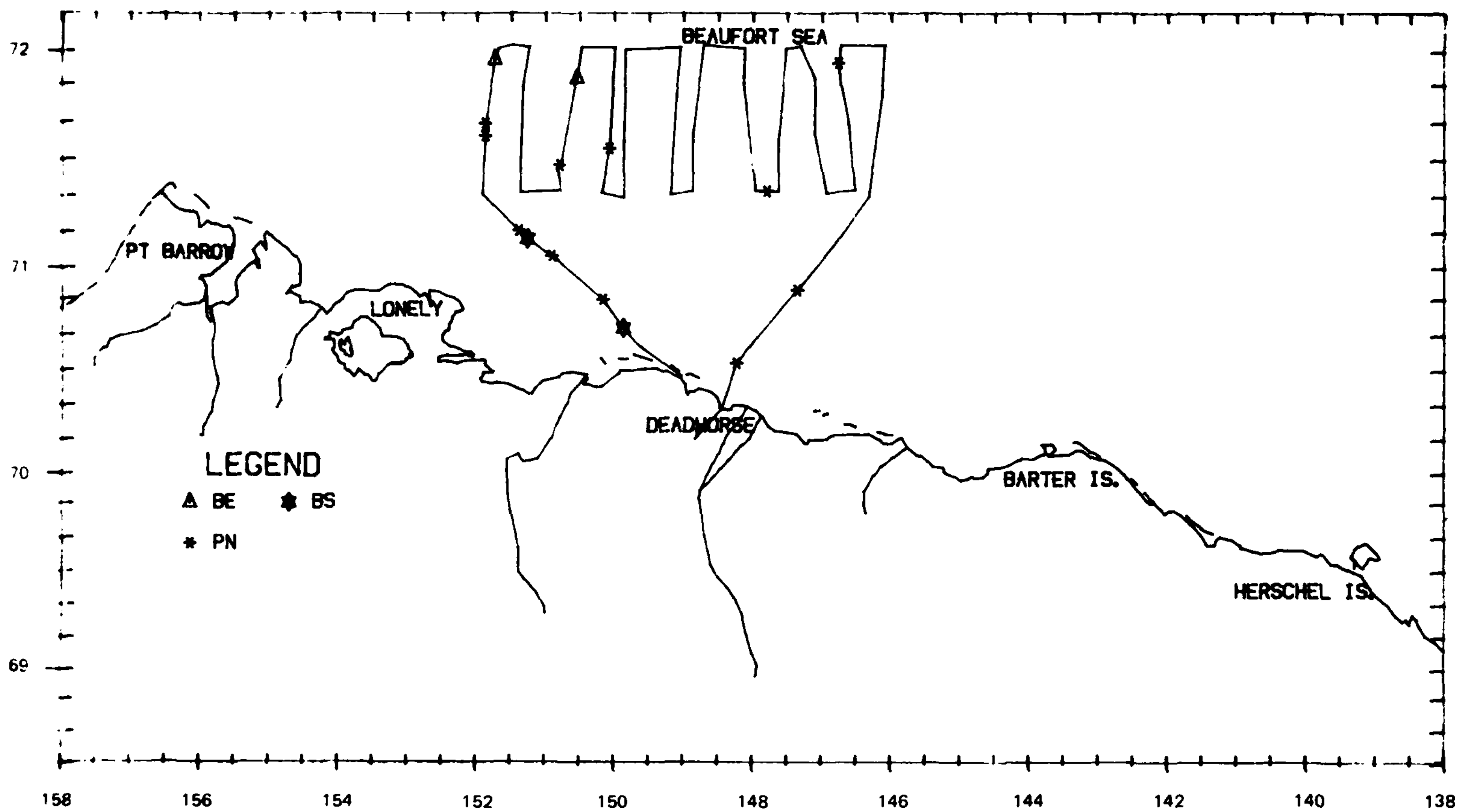
Flight 44: 28 August 1983

Flight was a transect survey of block 10 and half of block 11. Weather was overcast with unlimited visibility. Ice coverage was 9/10 broken floe. Sea state varied from Beaufort 01 to 03. Belukhas, unidentified pinnipeds, and bearded seals were seen. One sonobuoy was dropped and ambient sounds were recorded.


BEAUFORT SEA
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HERSCHEL IS.
LEGEND
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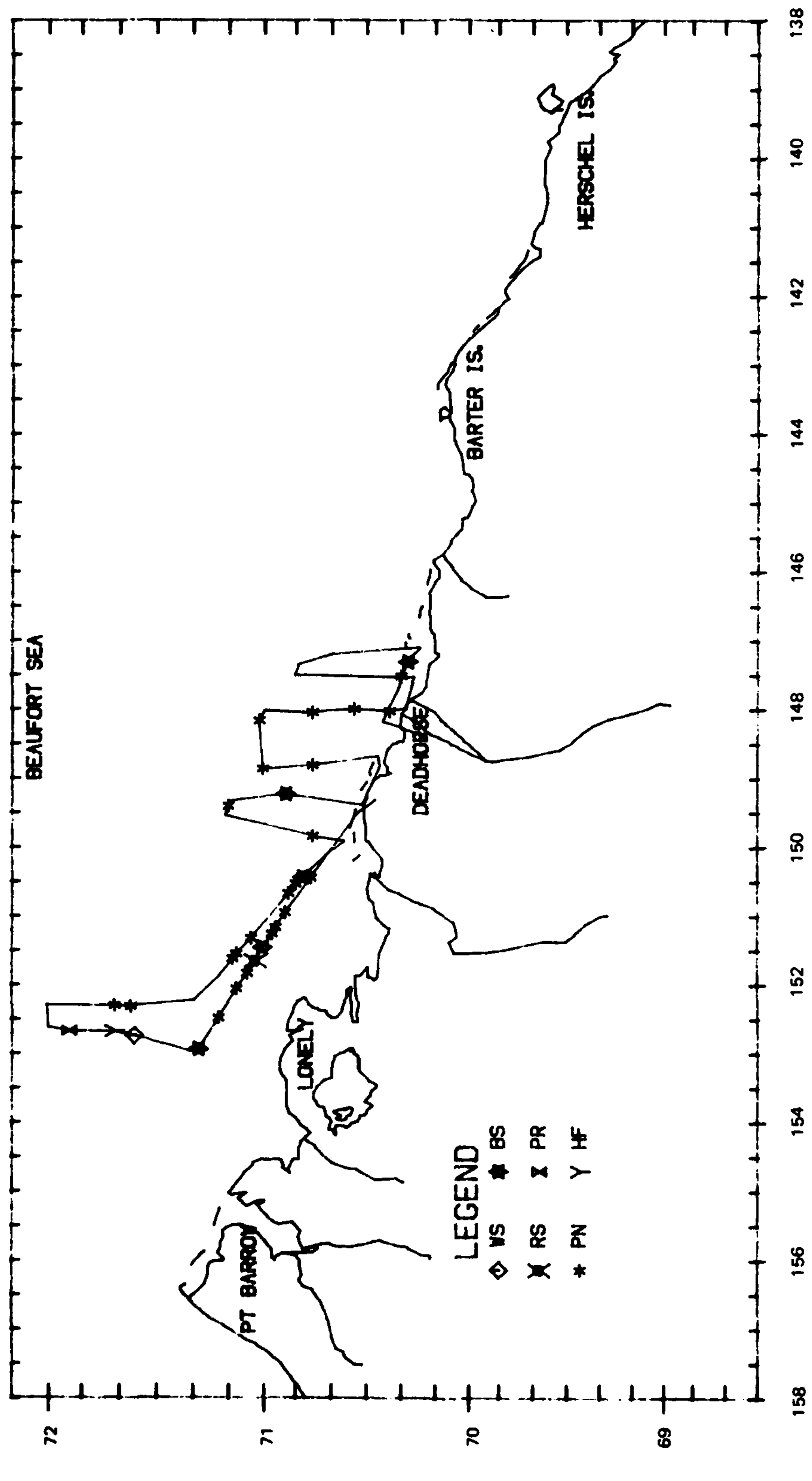
Flight 45: 29 August 1983

Flight was a transect survey of block I and part of block II. Weather was overcast with unlimited visibility. Ice coverage was 5/10 to 9/10 broken floe with sea state Beaufort 00 to 01. Walruses, bearded seals, a ringed seal, a ribbon seal, unidentified pinnipeds, and a polar bear were seen.



BEAUFORT SEA
PT BARROW
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DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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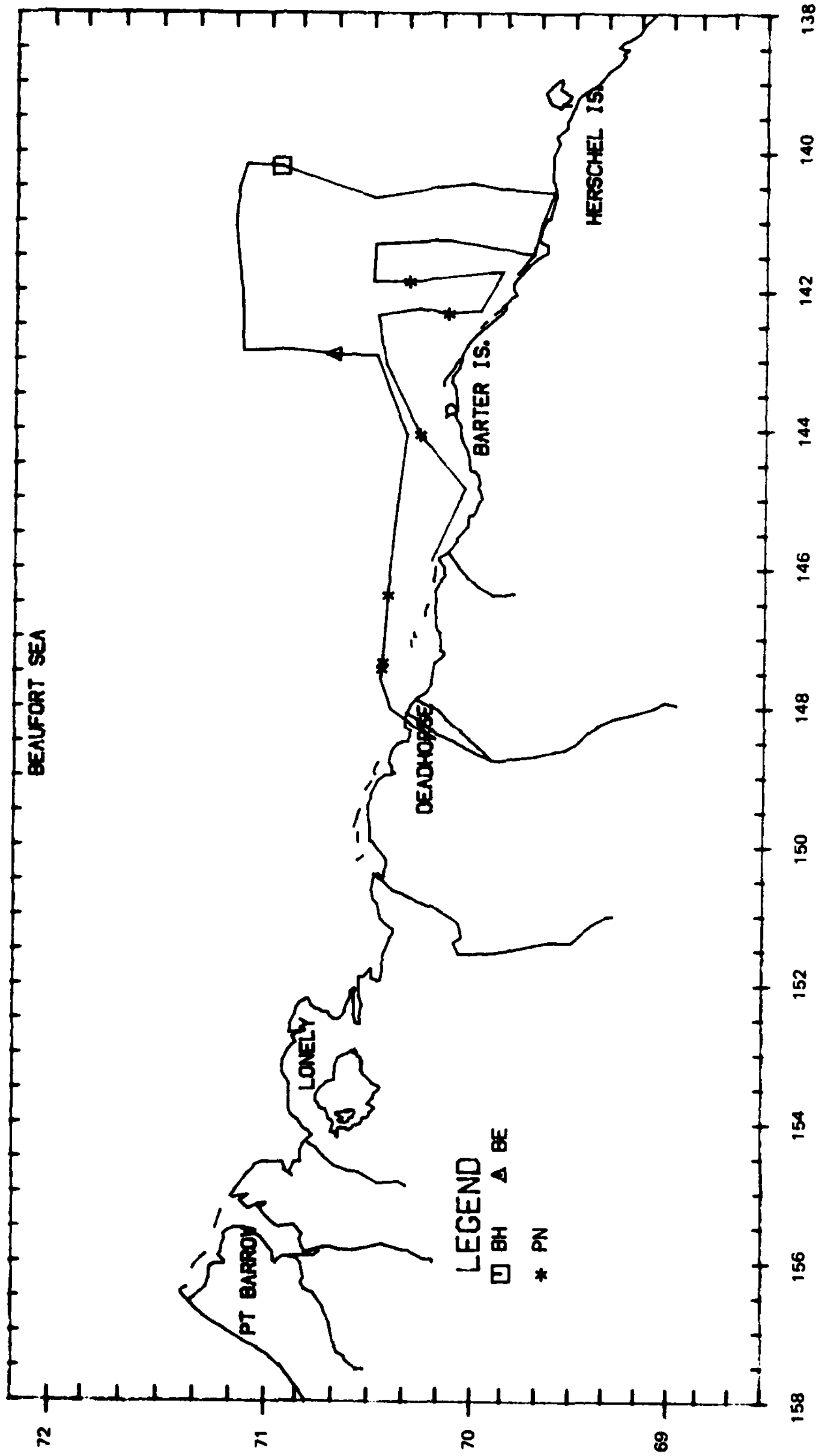
Flight 46: 30 August 1983

Flight was a transect survey of block 5 after attempting block 7. Weather was patchy fog with visibility 1 to 10 km. There were patches of 1/10 to 2/10 ice coverage in mostly open water. Sea states ranged from Beaufort 00 to 03. One bowhead, belukhas, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°56.0'	140°11.9'	838	BW	SW	-	0	B3	2012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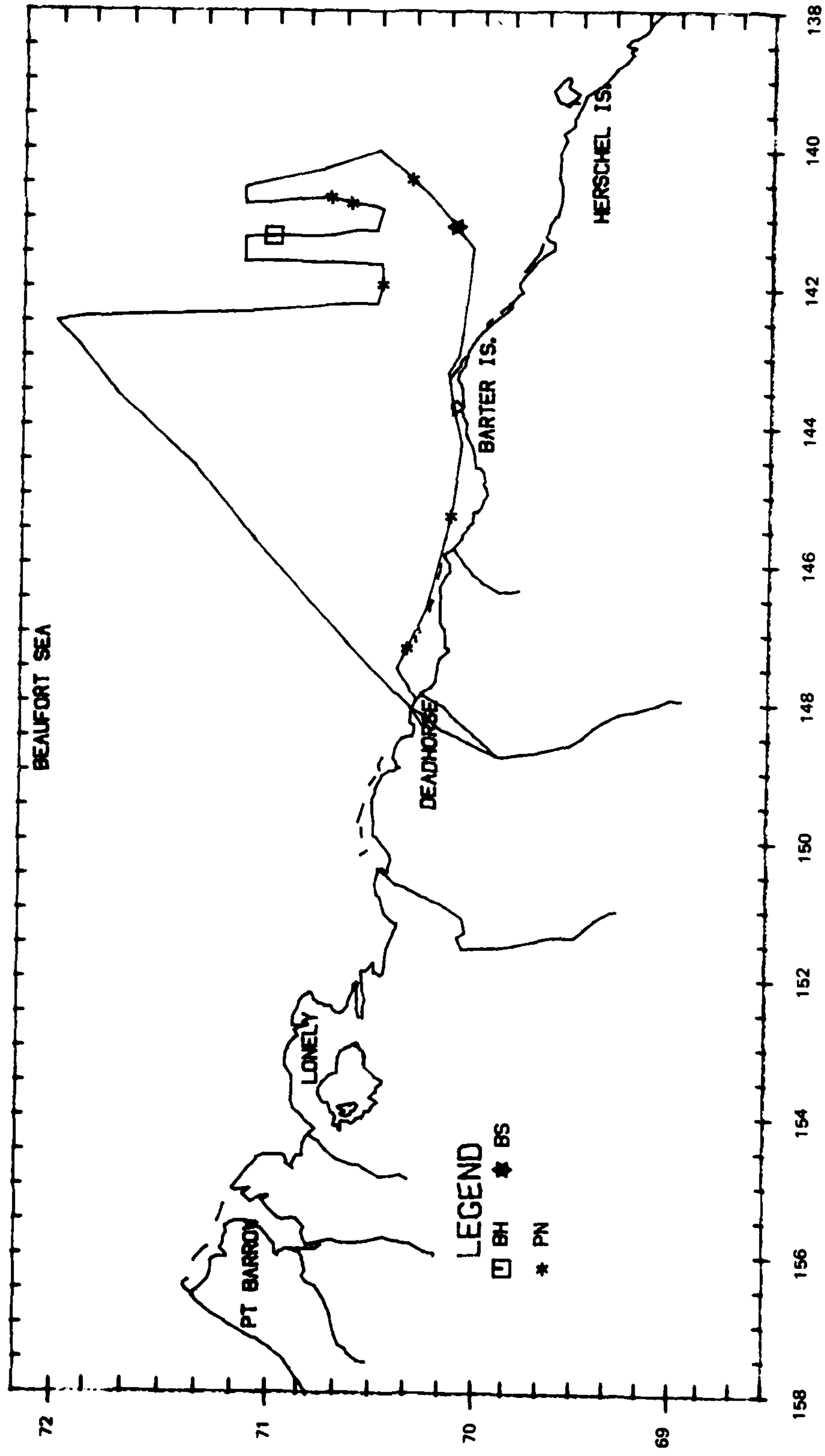
Flight 47: 31 August 1983

Flight was a transect survey of block 7 after attempting block 8. Weather was clear with unlimited visibility. Ice coverage was patchy 9/10 broken floe ice in mostly open water with sea state Beaufort 00 to 02. A bowhead cow-calf pair, a bearded seal, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/1	71°01.4'	141°15.0'	-	BO	CC	90	7	B1	2378


BEAUFORT SEA
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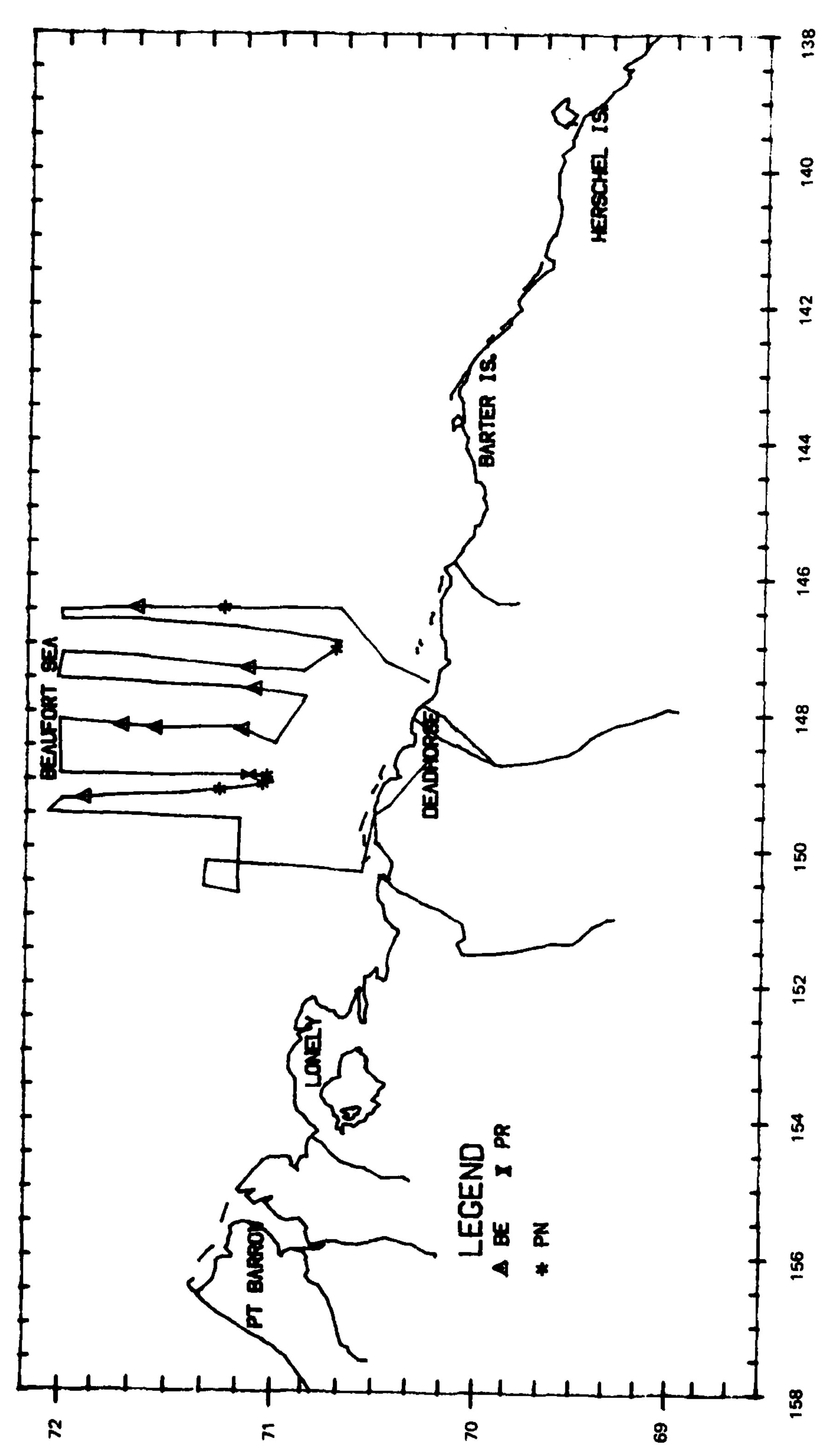
Flight 48: 2 September 1983

Flight was a transect survey of blocks 2 and 10 after attempting block 3. Weather was fog with 3 to 5 km visibility. Ice coverage was 9/10 broken floe with sea state Beaufort 01. Belukhas, polar bears, and unidentified pinnipeds were seen.


BEAUFORT SEA
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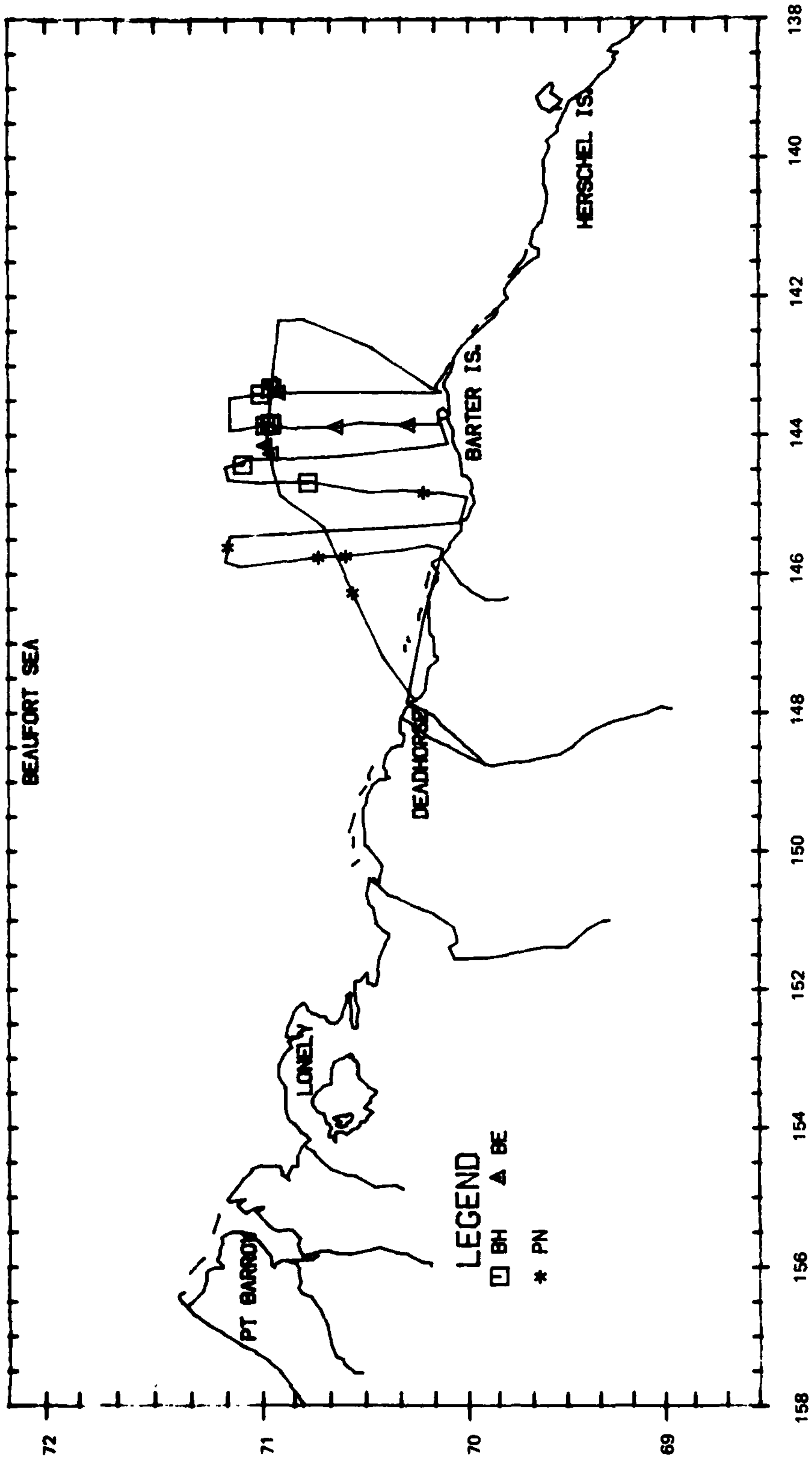
Flight 49: 3 September 1983

Flight was a transect survey of blocks 4 and 6. Weather was partly cloudy with unlimited visibility. Ice coverage was 8/10 broken floe with sea state Beaufort 01 to 03. Nine bowheads, including two calves, were seen swimming to the south and west in a lead near the 71°N latitude line. Belukhas and unidentified pinnipeds were also seen. A sonobuoy was dropped, but only ambient sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°56.1'	143°20.0'	1246	BO	SW	240	7	B2	732
1/0	70°59.0'	143°25.3'	813	BO	SW	260	7	B2	1464
2/0	70°56.4'	143°50.5'	-	BO	SW	180	8	B1	641
2/1	70°56.0'	143°51.7'	-	BO	CC	-	8	B1	641
1/1	70°57.7'	143°52.3'	-	BO	SW	270	8	B1	641
1/0	71°05.3'	144°26.5'	2197	SP	SW	170	9	B1	1281
1/0	70°46.0'	144°41.8'	1816	BO	DI	190	9	B1	348


BEAUFORT SEA
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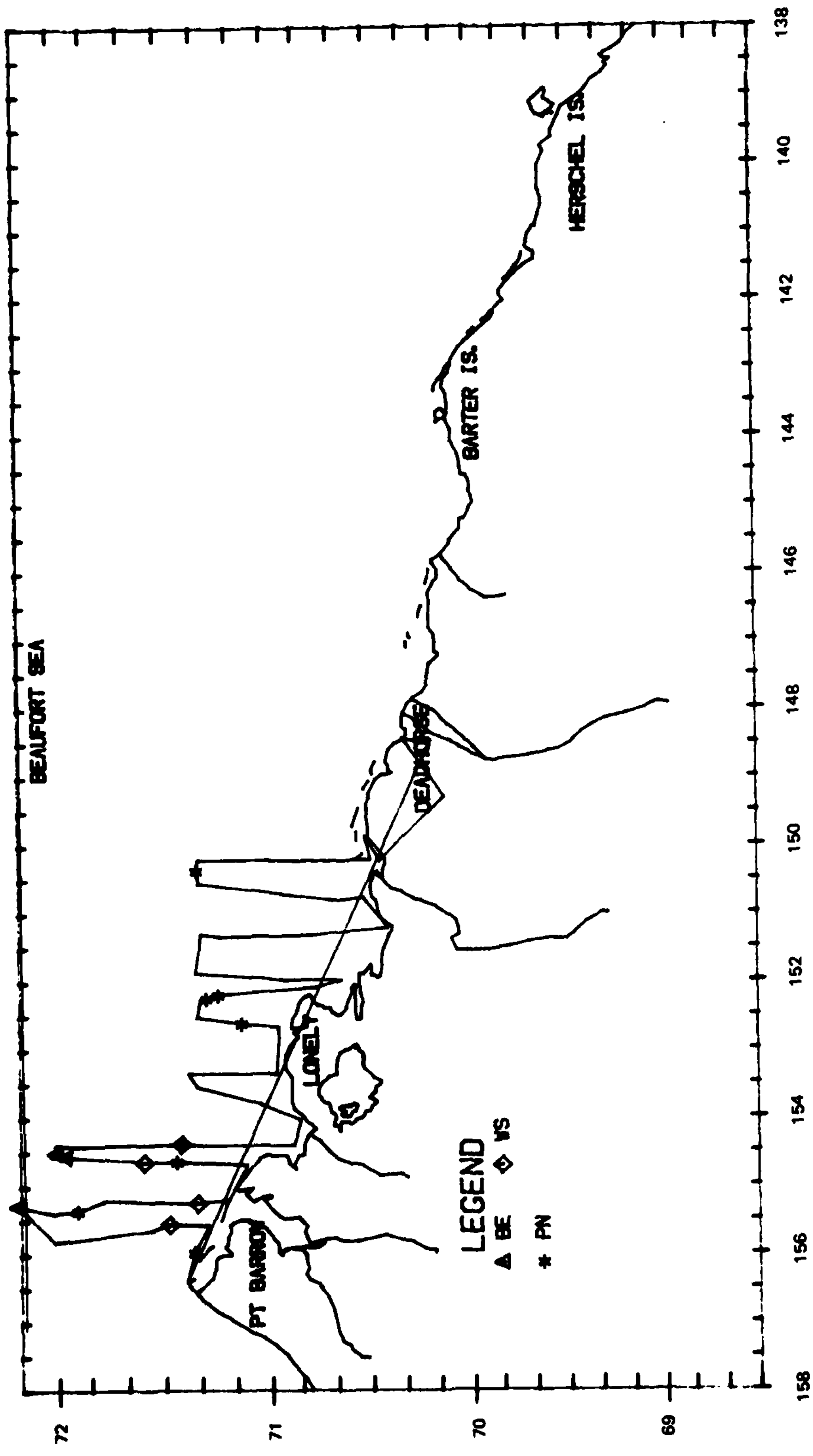
Flight 50: 5 September 1983

Flight was a transect survey of blocks 3 and 12. Weather was overcast with unlimited visibility. Ice coverage was 9/10 broken floe with open water nearshore. Sea state was Beaufort 01 in the ice, and Beaufort 03 nearshore. Belukhas, walruses, and unidentified pinnipeds were seen.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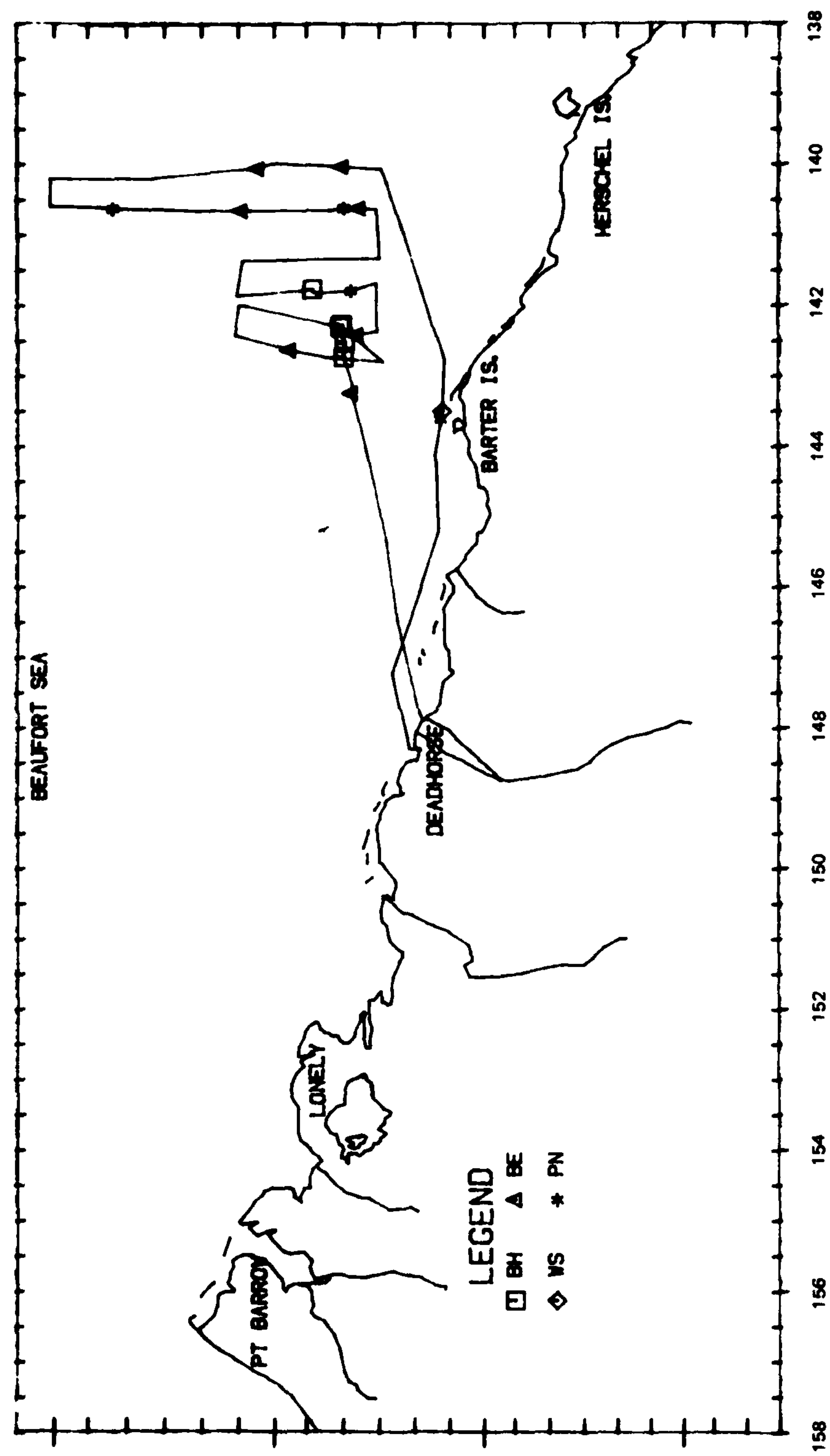
Flight 51: 6 September

Flight was a transect survey of block 7 and part of block 8. Weather was partly cloudy and visibility unlimited. Ice coverage ranged from open water nearshore to 9/10 in block 8. Sea state was Beaufort 00 to 03. Five bowheads were seen; one breached at least 13 times. Belukhas, walruses, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°48.5'	141°17.5'	488	BO	SW	170	6	B1	1921
1/0	70°40.9'	142°19.3'	1138	DY	FS	350	6	B1	1098
1/0	70°40.3'	142°17.5'	-	BO	BR	350	6	B1	1098
1/0	70°39.9'	142°32.2'	256	BO	RE	120	7	B1	670
1/0	70°40.1'	142°44.8'	1031	BO	DI	210	8	B1	366



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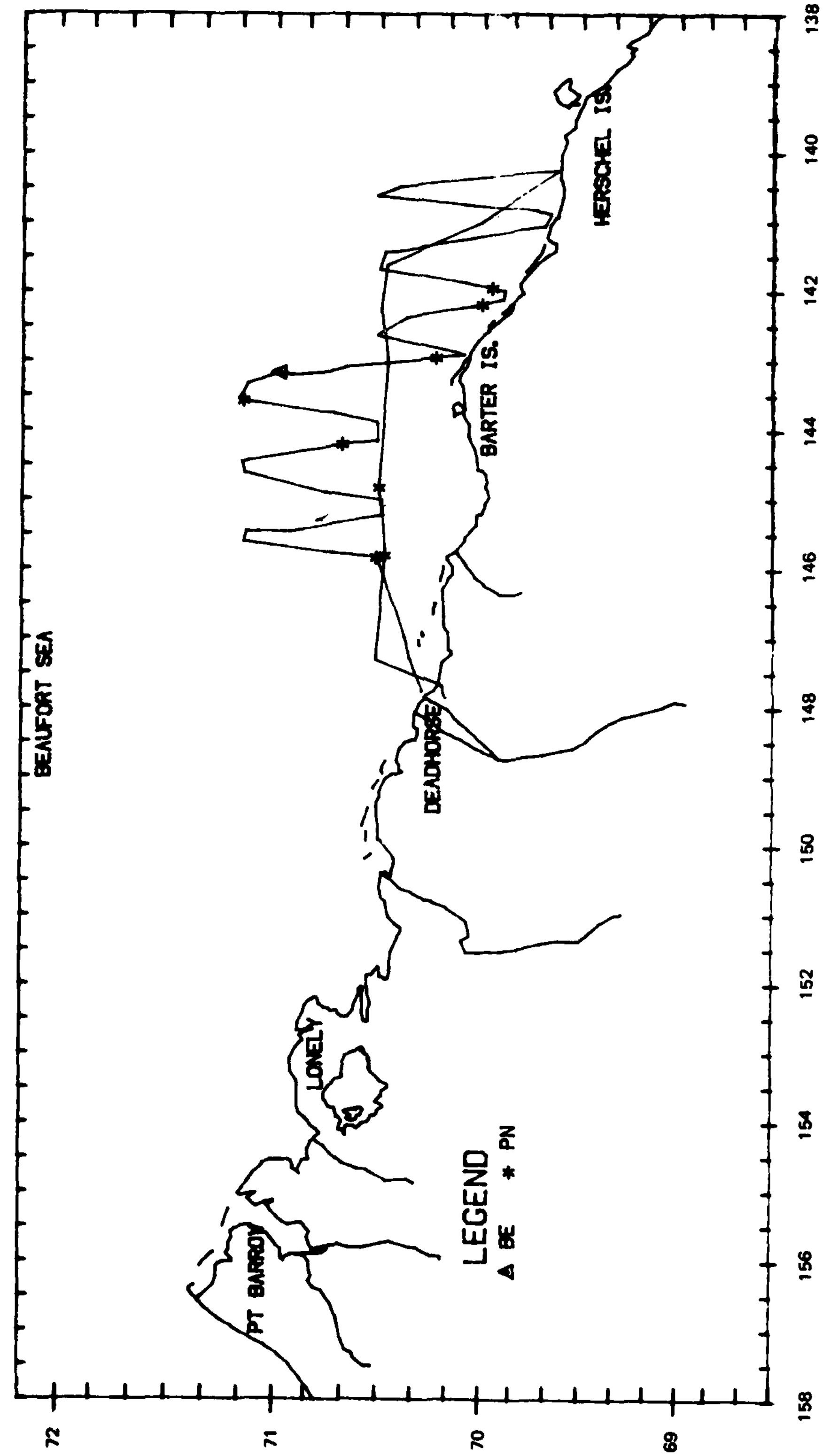
Flight 52: 7 September 1983

Flight was a transect survey of block 5 and 6. Weather was overcast and visibility unlimited. Ice coverage ranged from open water nearshore to 5/10 to 9/10 in the survey block. Sea state was Beaufort 00 to 04. A belukha and unidentified pinnipeds were seen.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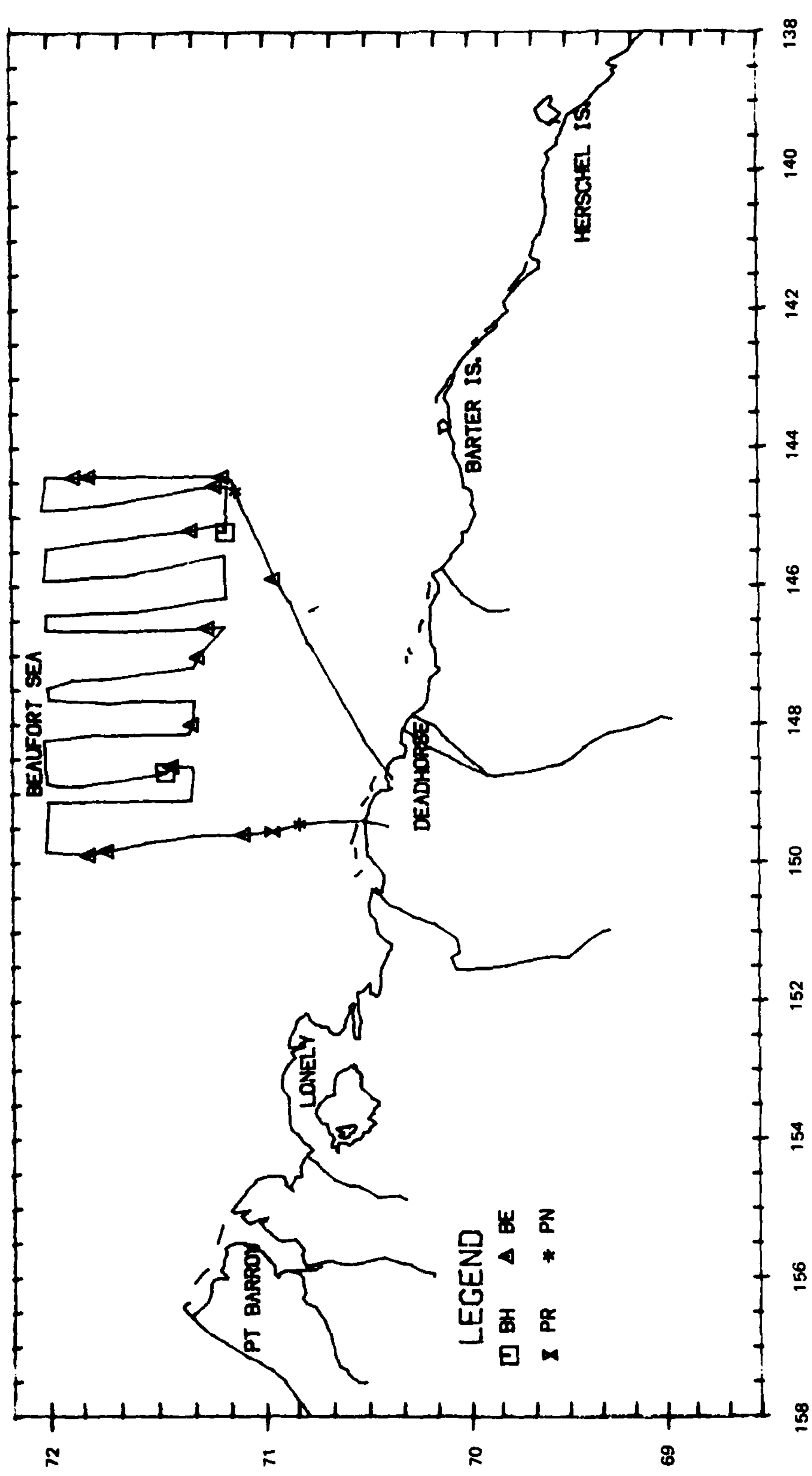
Flight 53: 8 September 1983

Flight was a transect survey of blocks 9 and 10. Weather ranged from fog to partly cloudy, and visibility was from unlimited to unacceptable. Ice coverage ranged from open water nearshore to 6/10 to 9/10 in the survey blocks. Sea state was Beaufort 01 to 02. Two bowheads were seen, one in each block. Belukhas, unidentified pinnipeds, and a polar bear were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°10.5'	144°12.0'	138	BO	SW	030	7	B1	1994
1/0	71°28.0'	147°39.7'	294	BO	RE	270	7	B1	2341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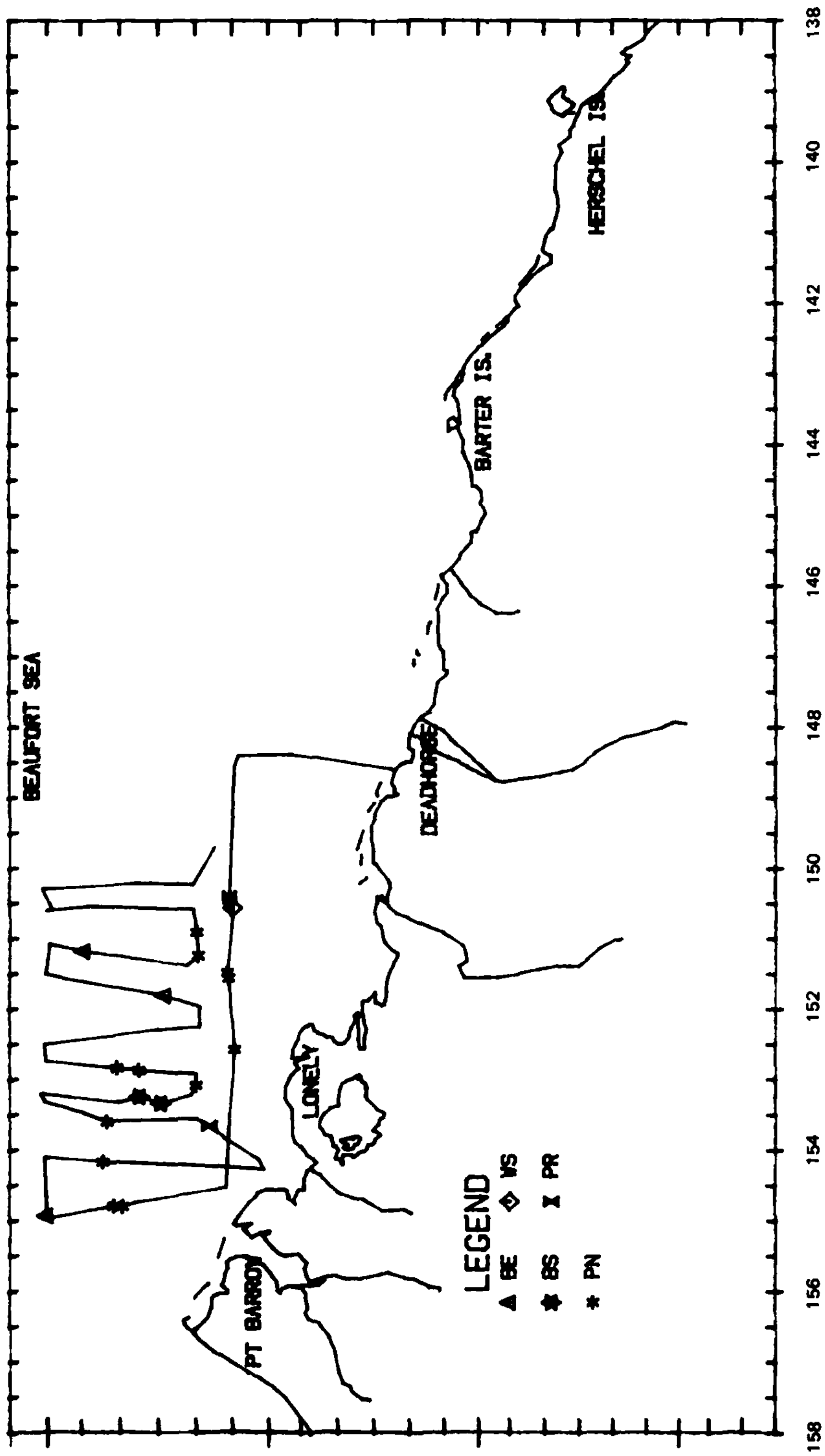
Flight 54: 9 September 1983

Flight was a search survey along the 71°10'N latitude line, and a transect survey of block 11, and the eastern third of block 12. Weather was low overcast with fog. Visibility ranged from unlimited to unacceptable. Ice coverage was 3/10 to 9/10 with the exception of a 25 km open water strip nearshore where sea state ranged from Beaufort 03 to 05. Belukhas, bearded seals, walruses, unidentified pinnipeds, and polar bears (five gathered at a kill site) were seen.



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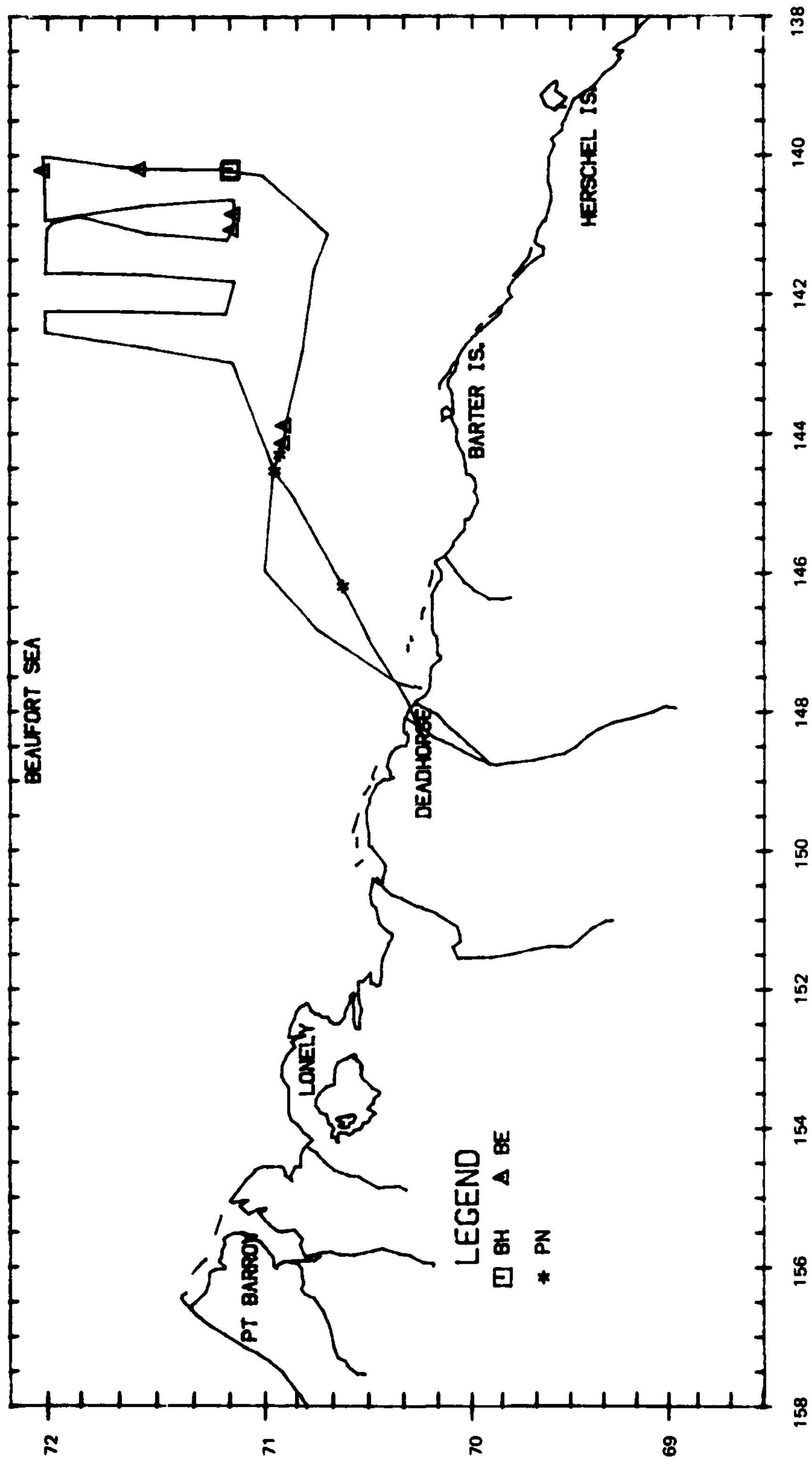
Flight 55: 10 September

Flight was a transect survey of block 9 and a search of blocks 7 and 6 along the 1200-m isobath. Weather was partly cloudy with areas of low ceiling. Visibility was unlimited. Ice coverage was 4/10 to 9/10 in block 9; open water to 9/10 overall. Sea state ranged from Beaufort 00 to 02. One cow-calf bowhead pair was seen. Belukhas and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/1	71°09.6'	140°13.6'	893	BO	CC	120	6	B0	1976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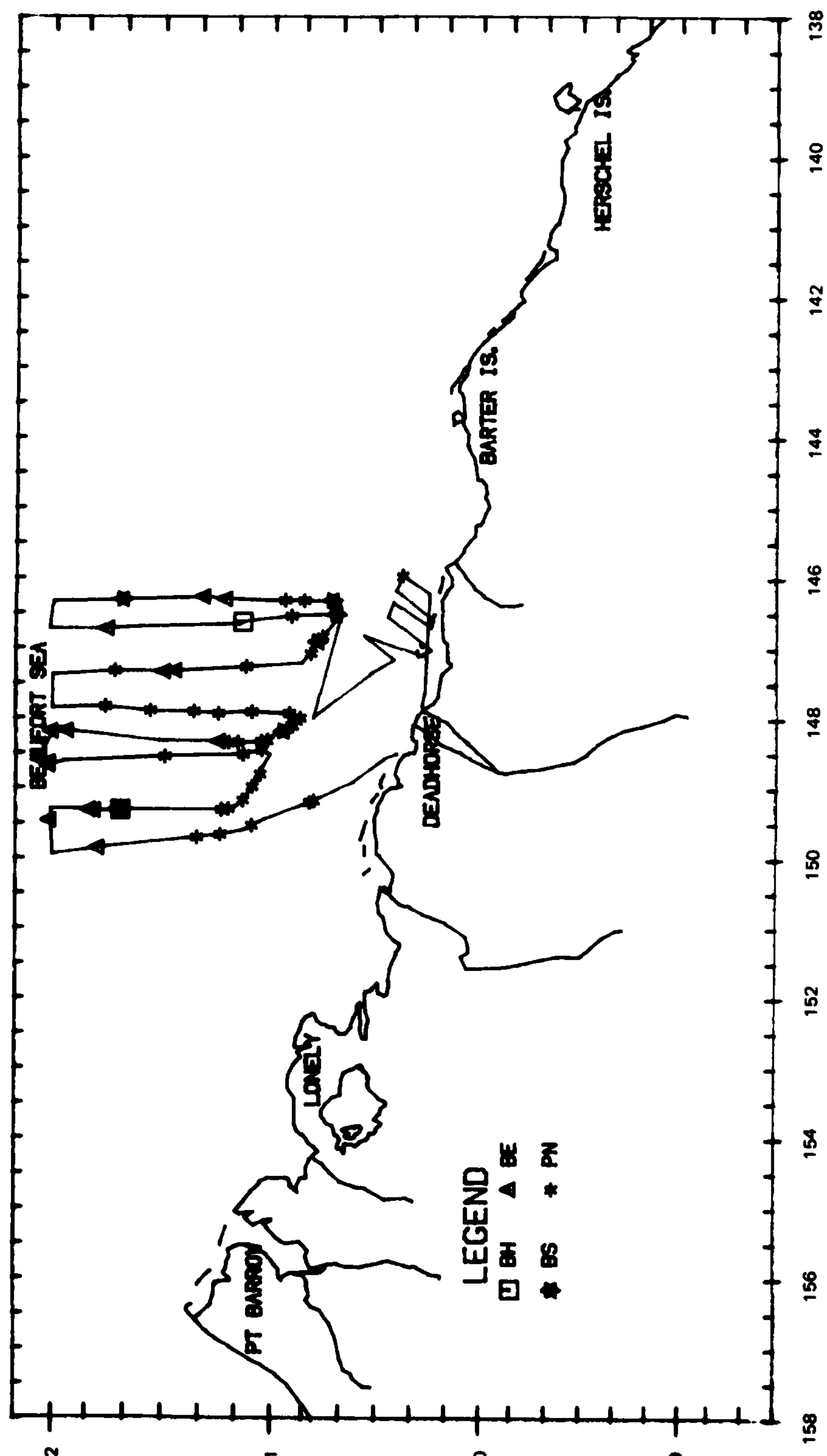
Flight 56: 13 September 1983

Flight was a transect survey of blocks 2 and 10 with a search to, and short transect survey near, a seismic vessel in block 1. Weather was clear and visibility was unlimited. Ice coverage was 2/10 to 7/10 in blocks 2 and 10. Open water extended approximately 40 km offshore through most of block 1. Sea state ranged from Beaufort 00 to 01. Two bowheads, belukhas, bearded seals, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°41.2'	149°18.8'	207	BO	DI	-	5	B1	2950
1/0	71°08.4'	146°37.8'	198	BO	RE	330	5	B1	2210



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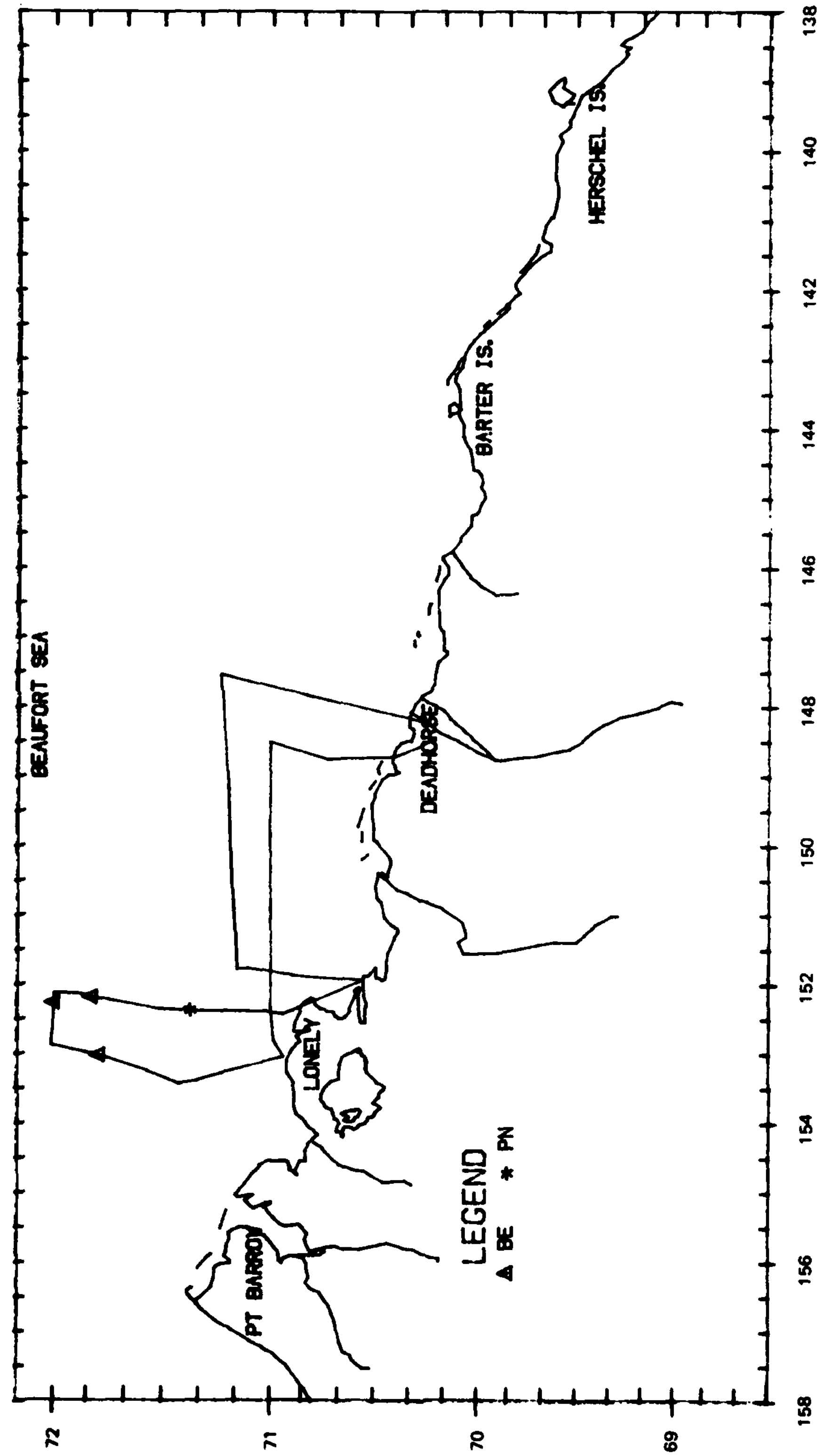
Flight 57: 14 September 1983

Flight was a search west of Deadhorse along the 71°N latitude line, a partial transect of the western ends of blocks 3 and 11, and a search back to Deadhorse along the 71°10'N line. Weather was fog with clear patches. The fog became so thick that the transect, and then the search survey, were aborted. Ice coverage ranged from open water to 8/10 and sea state from Beaufort 01 to 02. Belukhas and unidentified pinnipeds were seen.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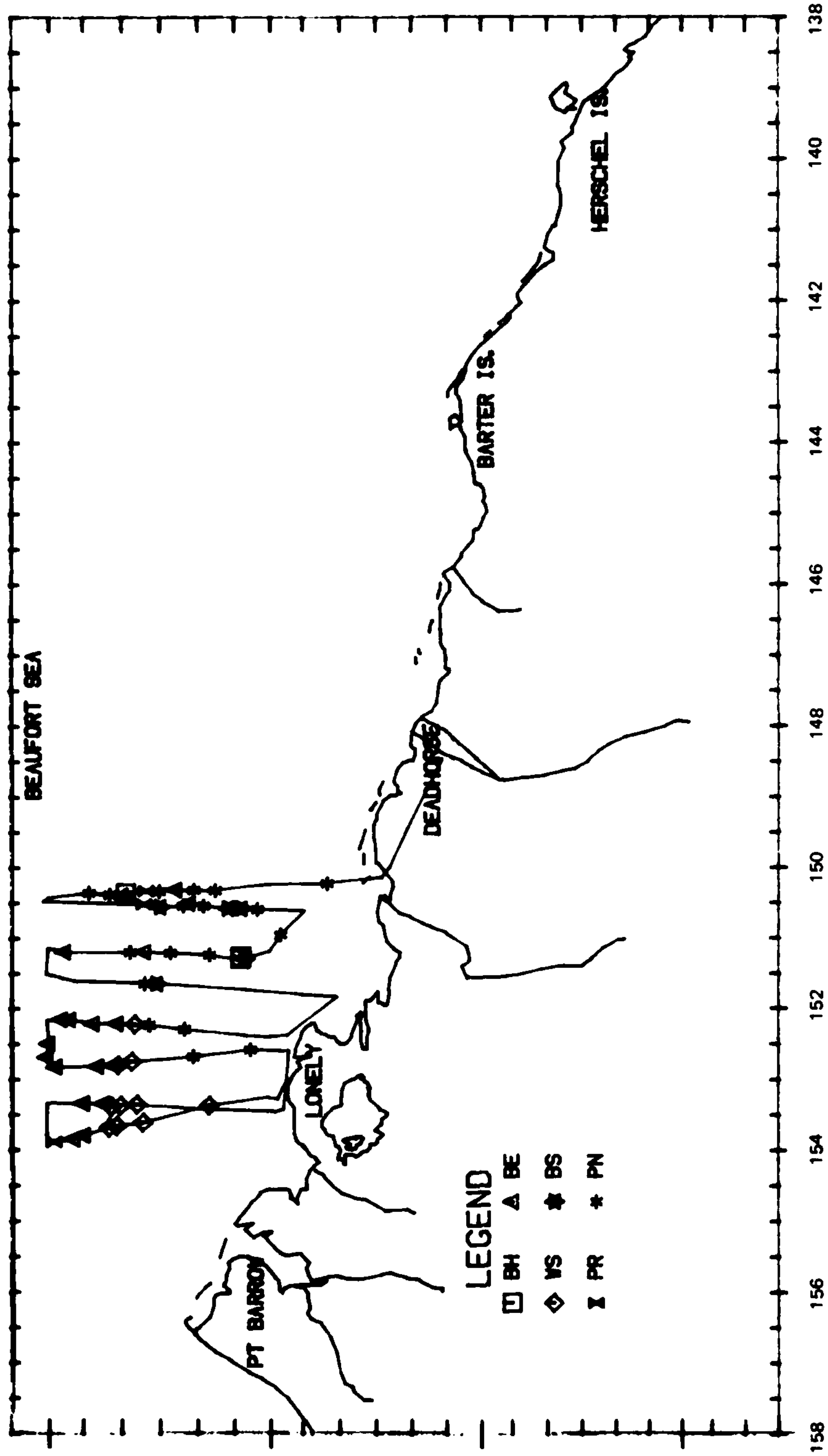
Flight 58: 15 September 1983

Flight was a transect survey of blocks 3 and 11. Weather was low overcast with patches of fog; visibility ranged from unlimited to unacceptable. Ice coverage was open water to 8/10 in block 3, open water to 9/10 in block 11. Sea state was Beaufort 01 to 02. Four bowheads were sighted, one in block 11 and three in block 3. Belukhas, bearded seals, walruses, unidentified pinnipeds, and polar bears were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°39.0'	150°21.5'	128	BO	DI	-	8	B1	2640
3/0	71°08.5'	151°17.2'	217	SP	SH	210	6	B1	46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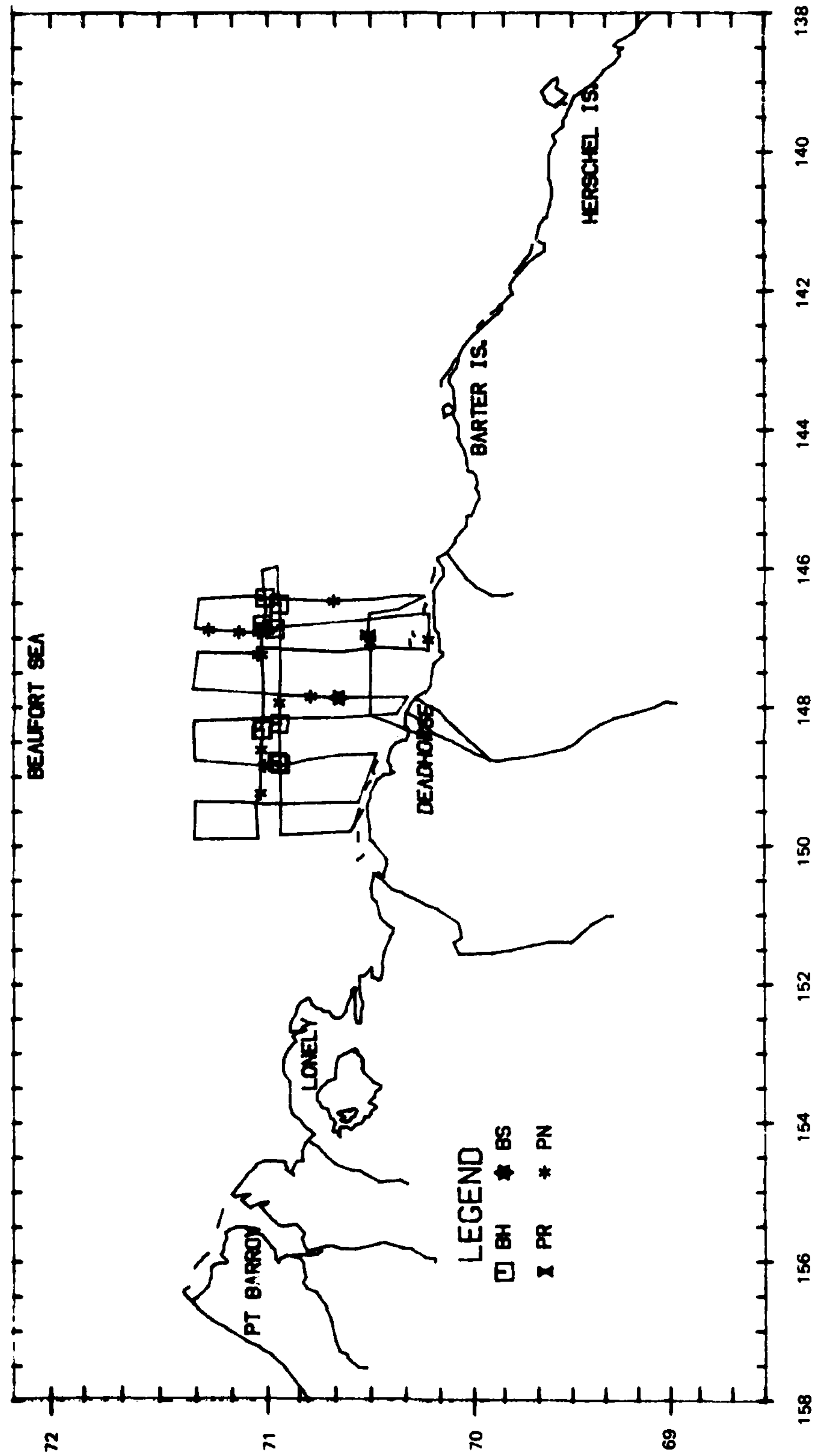
Flight 59: 16 September 1983

Flight was a transect survey of blocks 1 and 2 and an east-west search survey at the 71°N and 70°55'N latitude lines. Weather was low overcast with patches of fog. Visibility ranged from less than 1 km to unlimited. Ice coverage was open water to 9/10. Sea state was Beaufort 01 to 03. Seven bowheads were seen; one breached five times. A bearded seal, polar bear, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	71°00.4'	146°25.7'	288	BO	DI	240	8	B1	510
1/0	70°56.3'	146°52.5'	500	BO	SW	270	4	B1	98
1/0	70°59.4'	148°19.9'	-	DY	BR	020	6	B1	37
1/0	70°59.6'	146°48.6'	366	SP	SW	240	6	B1	66
1/0	70°55.1'	146°31.4'	792	SP	SW	240	7	B1	82
1/0	70°55.1'	148°14.6'	1005	SP	DI	240	6	B1	37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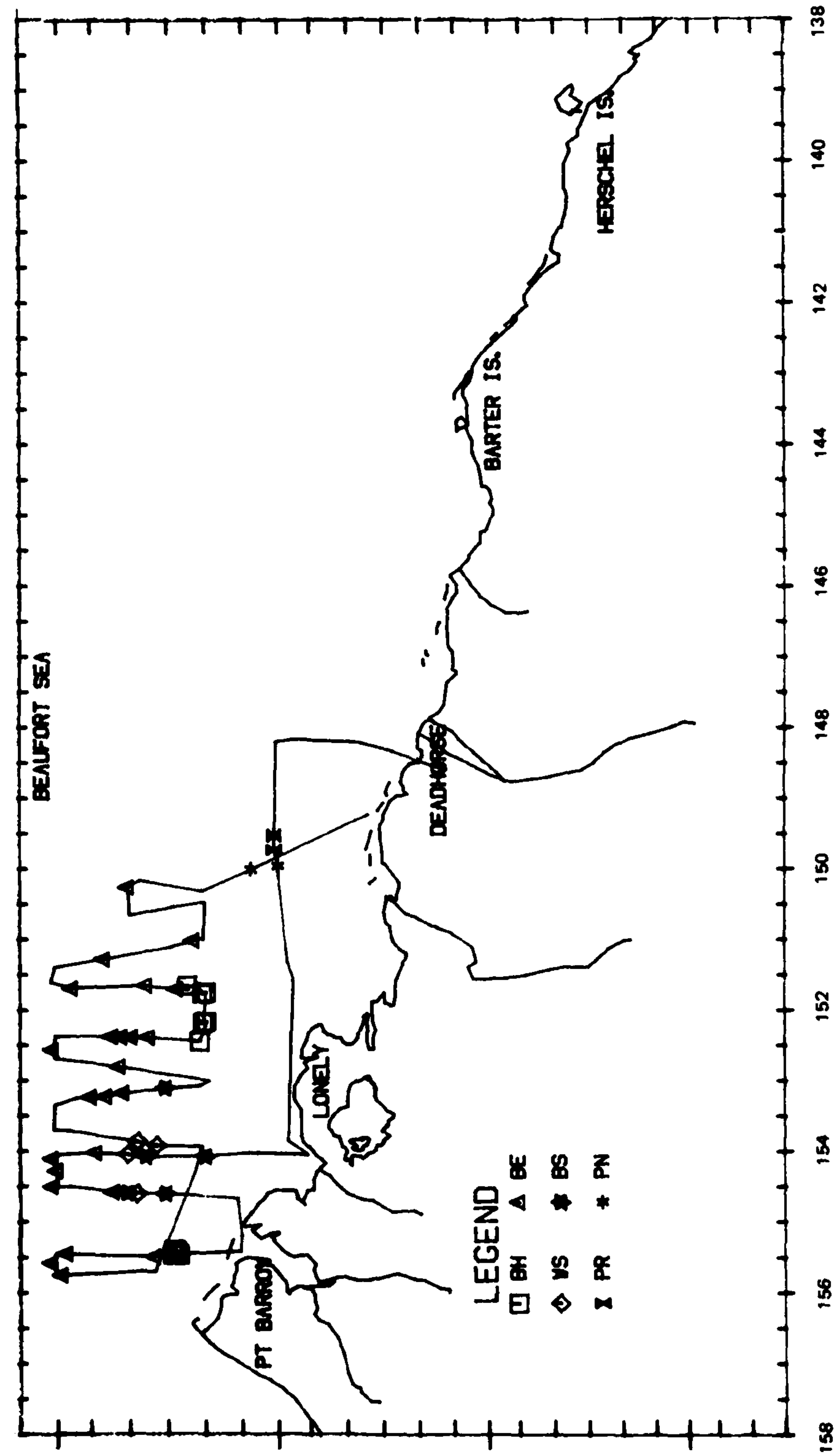
Flight 60: 18 September 1983

Flight was a transect survey of the eastern half of block 12 and block 11. Weather was overcast with increasing fog to the north and west. Visibility ranged from unlimited to unacceptable. Ice coverage ranged from open water to 9/10, and sea state from Beaufort 00 to 03. Thirteen bowheads, including one calf, were seen, seven in block 12 and six in block 11. One whale tail-slapped in 3 to 4 minute bouts for approximately 17 minutes, punctuating the tail slaps with breaches (10 times), head lunges (2 times), and flipper slaps (1 time). Two nearby whales appeared to be headed toward the displaying whale; all others held westerly headings. Belukhas, bearded seals, walruses, unidentified pinnipeds, and polar bears were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°27.6'	155°24.8'	-	SP	TS	240	0	B1	20
1/0	71°27.7'	155°27.2'	-	SP	BR	030	0	B1	20
2/0	71°26.9'	155°27.1'	143	SP	TS	-	0	B1	13
1/0	71°28.0'	155°23.6'	-	BW	SW	040	0	B1	20
2/0	71°28.6'	155°26.6'	-	BW	SW	270	0	B1	13
1/0	71°21.2'	152°26.3'	718	BO	SW	240	-	-	76
1/0	71°19.5'	152°09.5'	970	BO	SW	240	5	B1	76
1/0	71°20.4'	152°10.5'	-	BO	SW	240	4	B1	76
1/1	71°19.5'	151°44.7'	755	BO	SW	240	4	B1	76
1/0	71°20.5'	151°45.5'	-	BO	SW	240	4	B1	54
1/0	71°24.6'	151°38.8'	-	BO	SW	240	3	B1	54



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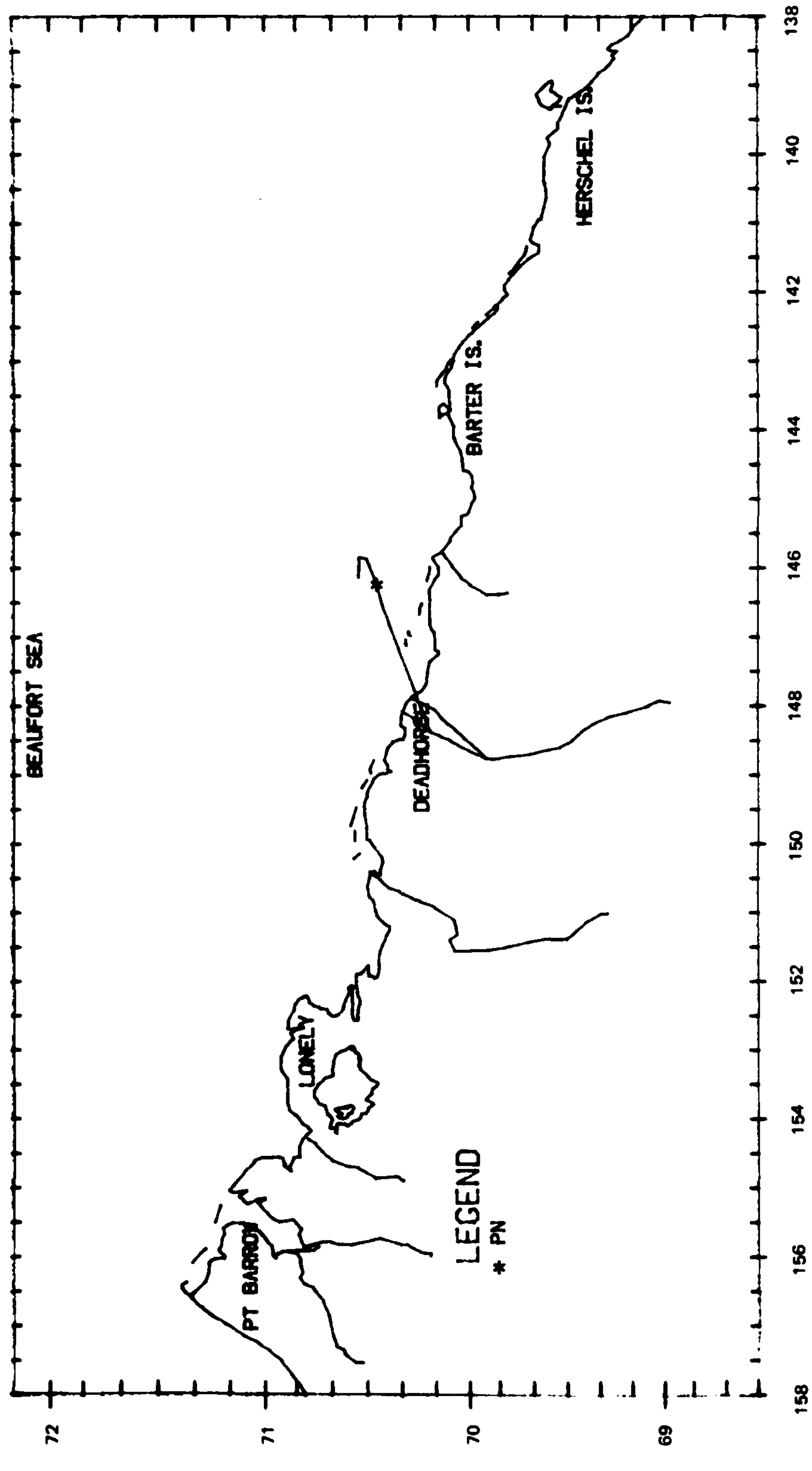
Flight 61: 19 September 1983

Flight was a search survey through block 1 towards block 6. Weather was low overcast with fog. Visibility ranged from 10 km to unacceptable. Ice coverage was open water to 6/10, and sea state Beaufort 01 to 02. A pinniped was seen before the flight was aborted due to persistent low, heavy fog.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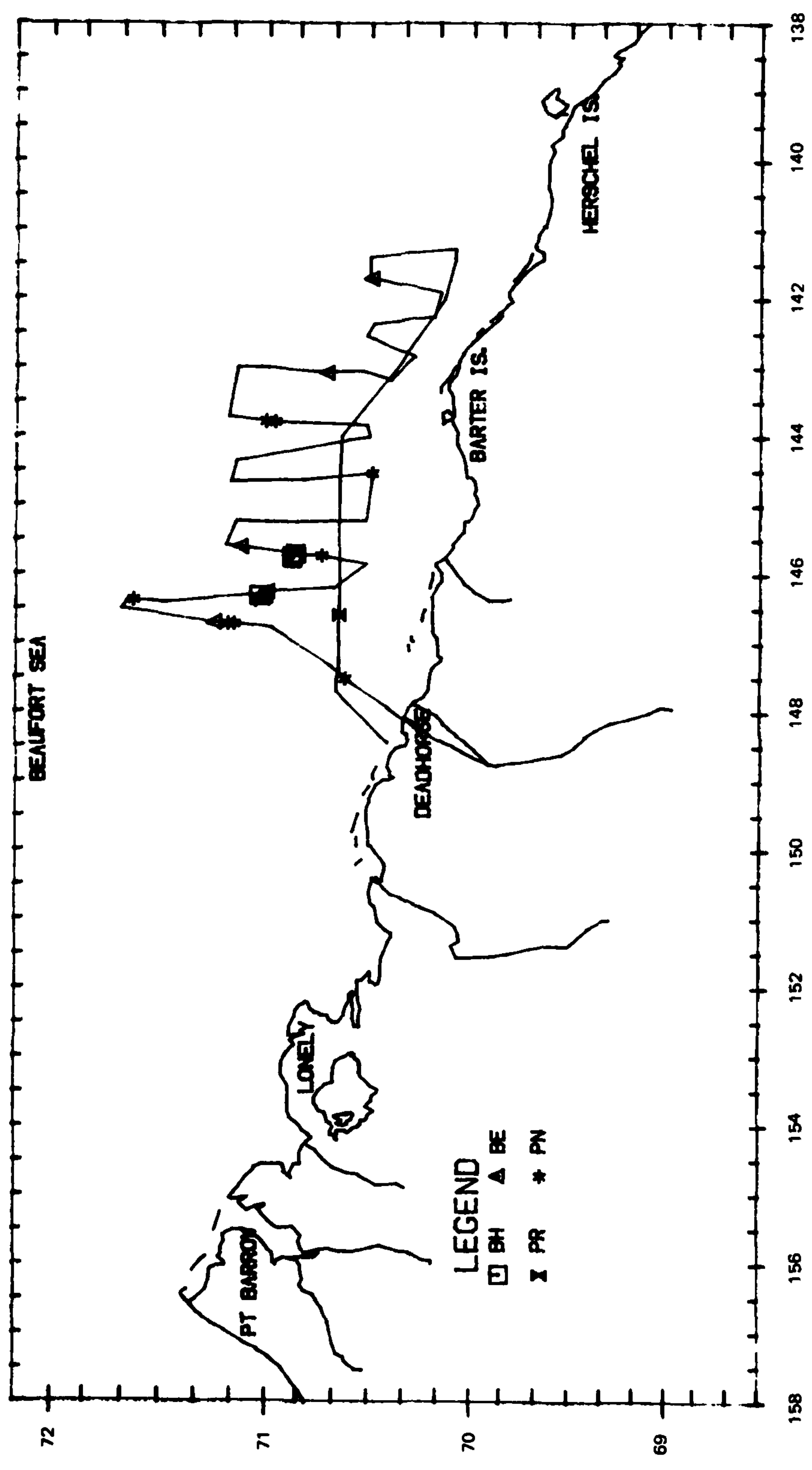
Flight 62: 21 September 1983

Flight was a transect survey of blocks 5, 6, and the eastern quarter of 2 and 10. Weather was partly cloudy with areas of heavy low fog causing some transects to be truncated. Visibility was mostly unlimited. Ice coverage ranged from 4/10 to 9/10 in the blocks, with sea state Beaufort 00 to 01. Six bowheads were seen including a cow-calf pair. One sonobuoy was dropped near the cow-calf pair but only a few faint bowhead sounds and belukha calls were recorded. Belukhas, a polar bear, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°50.7'	145°42.2'	2223	SP	SW	240	8	B1	274
2/0	70°51.9'	145°44.8'	-	SP	SW	240	7	B1	274
1/0	70°51.7'	145°46.1'	-	BW	SW	240	7	B1	274
2/1	71°02.5'	146°18.3'	1501	BW	CC	200	7	B1	1280



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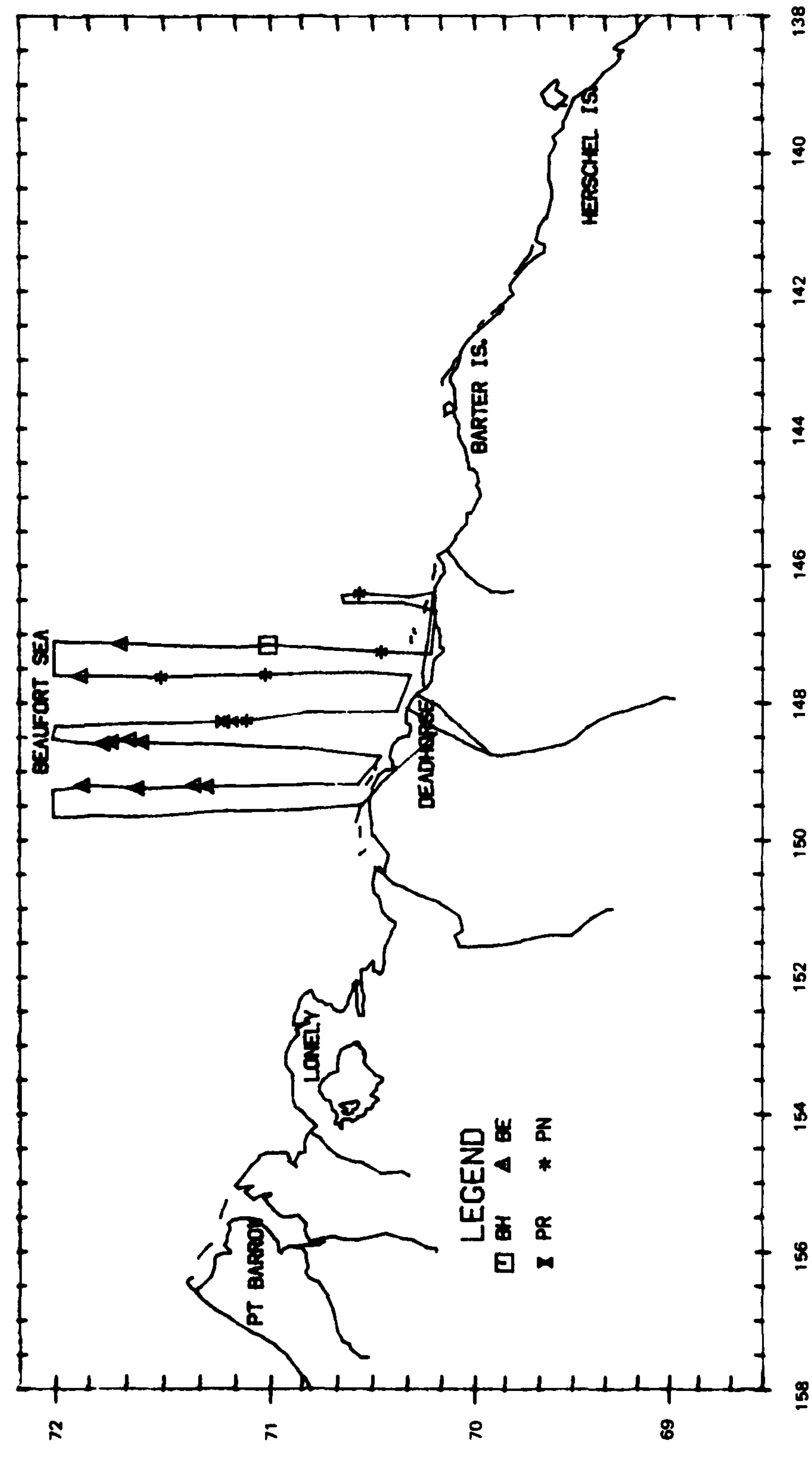
Flight 63: 22 September 1983

Flight was a transect survey of blocks 1, 2, and 10. Weather was overcast with scattered snow squalls. Visibility was generally unlimited. Ice coverage ranged from open water to 9/10, being heaviest in block 10. Sea state was Beaufort 01 to 03. One bowhead, belukhas, polar bears, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°59.2'	147°09.1'	1104	BO	DI	270	8	B1	58



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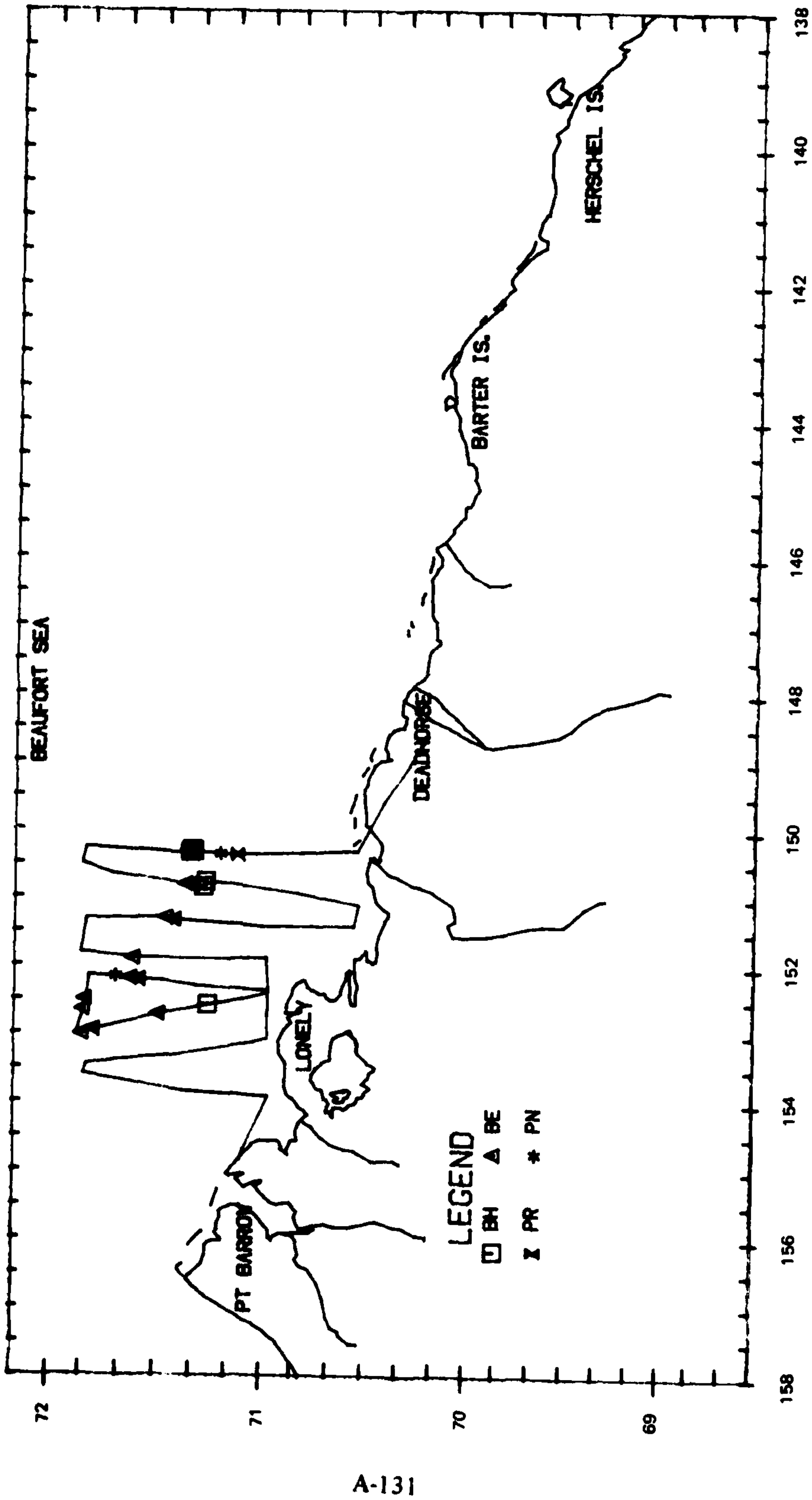
Flight 64: 23 September 1983

Flight was a transect survey of blocks 3 and 11. Weather was overcast with snow squalls and visibility ranged from unlimited to unacceptable. Ice coverage was 1/10 to 9/10 and sea state ranged from Beaufort 01 to 05. Five bowheads were seen, including a possibly nursing cow-calf pair. A sonobuoy was dropped, but no bowhead calls were recorded. Belukhas, polar bears, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/1	71°21.3'	150°19.5'	-	BO	CC	-	6	B3	400
1/0	71°20.3'	150°18.7'	746	BO	RO	240	5	B2	400
1/0	71°17.4'	150°50.0'	482	BO	SW	240	9	B1	360
1/0	71°16.8'	150°45.4'	-	BO	SW	240	8	B2	360
1/0	71°15.9'	152°33.8'	1104	BO	SW	240	9	B1	52



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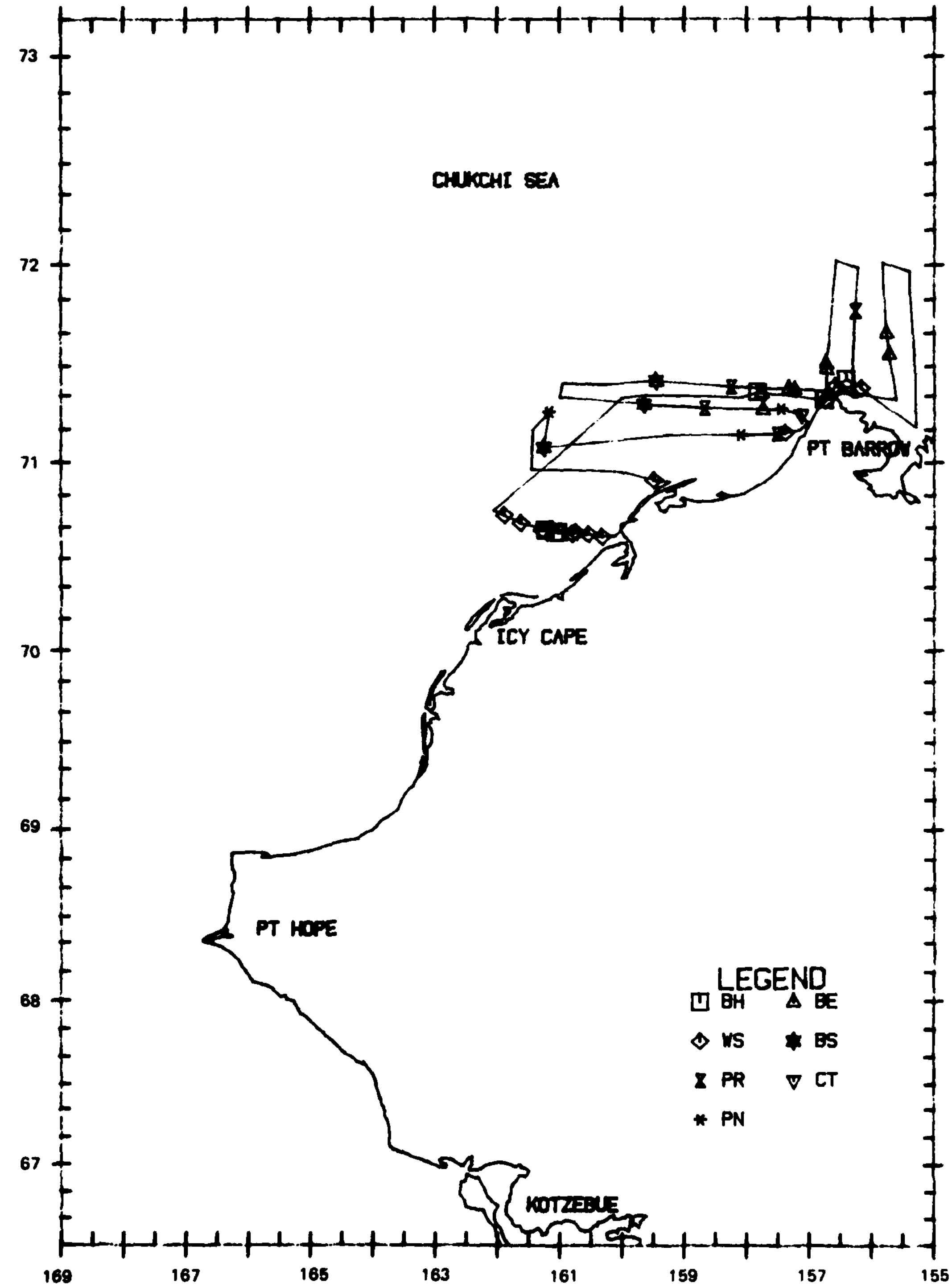
Flight 65: 24 September 1983

Flight was a transect survey of blocks 12, 13, and 17. Weather was overcast with snow squalls. Visibility ranged from unlimited to unacceptable. Ice coverage was 8/10 to 9/10 and sea state was Beaufort 01 to 03. Eleven bowheads were seen, seven nearshore in block 12, one in block 13, and three in block 17. One whale tail-slapped for approximately 10 minutes. A sonobuoy was dropped near this whale, but only ambient noise was recorded. Belukhas, bearded seals, walruses, polar bears, and unidentified pinnipeds were seen. One unidentified cetacean, possibly a bowhead, was also seen. This animal dove immediately in heavy ice conditions and was not resighted.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
4/0	71°18.9'	156°44.7'	-	BO	SW	240	7	B1	9
1/0	70°38.6'	161°01.1'	-	BO	DI	210	7	B1	22
3/0	71°25.1'	156°24.1'	-	BO	SW	270	9	B1	9
1/0	70°38.8'	161°04.7'	793	BO	SW	180	8	B1	9
1/0	70°39.5'	161°14.0'	832	BO	TS	250	7	B1	22
1/0	71°21.3'	157°49.3'	-	BO	SW	240	9	B1	35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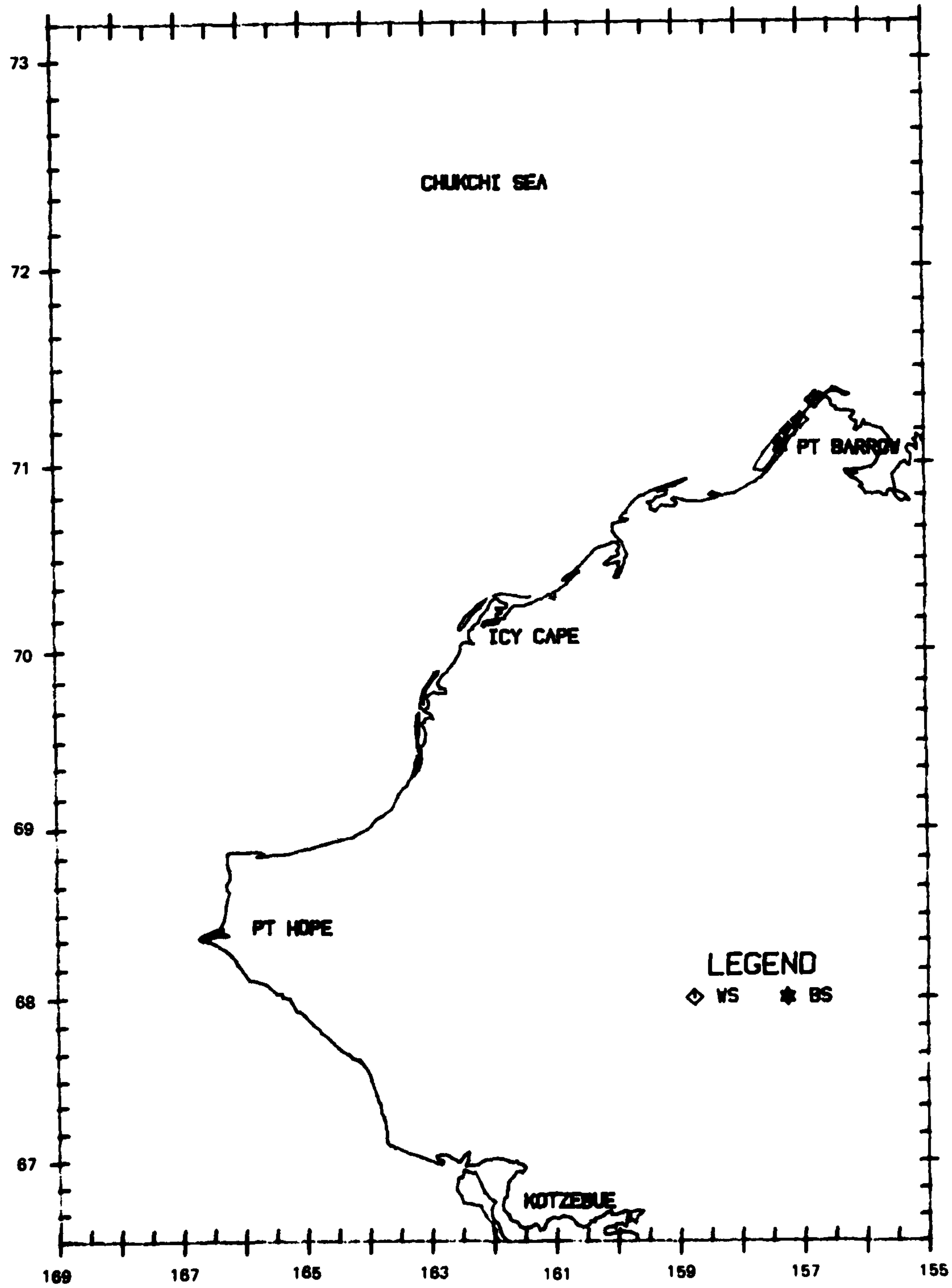
Flight 66: 25 September 1983

Flight was a short search survey in blocks 12 and 13 that was aborted due to icing conditions and fog. Weather was overcast with fog and visibility ranged from unacceptable to 10 km. Ice coverage was 9/10 and sea state Beaufort 01. Walruses and a bearded seal were seen.



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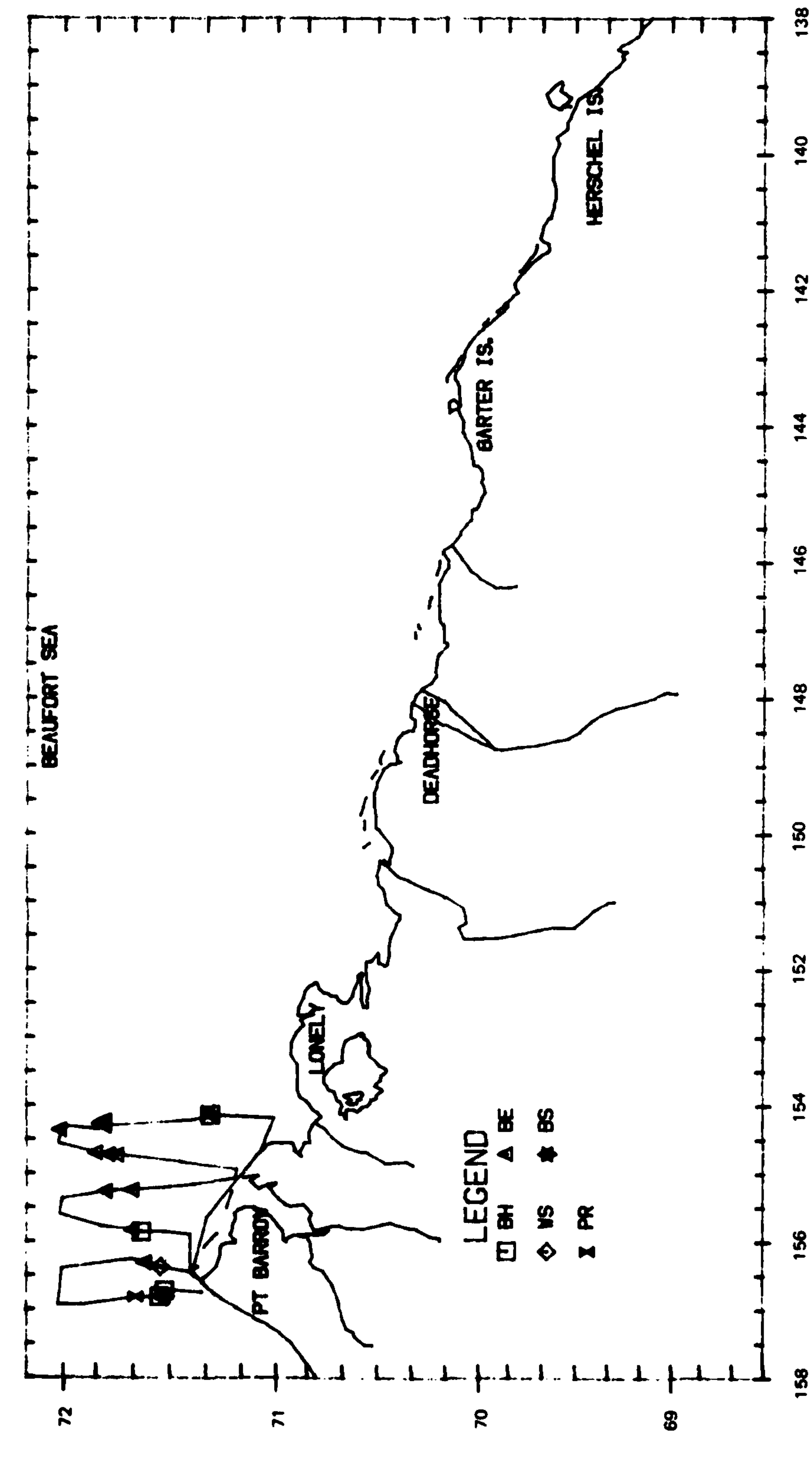
Flight 67: 26 September 1983

Flight was a transect survey of block 12. Weather was overcast with patches of fog. Visibility ranged from unlimited to unacceptable. Ice coverage was 1/10 nearshore to 9/10 offshore. Sea state was Beaufort 01 to 04. Four bowheads were seen swimming through 8/10 to 9/10 ice. Belukhas, a bearded seal, walruses, and polar bears were also seen. One sonobuoy was dropped and bowhead and faint belukha calls were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°18.5'	154°08.6'	1348	BW	SW	240	9	B2	24
1/0	71°37.5'	155°51.7'	658	BO	SW	210	8	B1	154
1/0	71°32.5'	156°48.7'	420	BO	SW	240	9	B1	128
1/0	71°31.1'	156°43.2'	276	BO	SW	150	8	B1	55


BEAUFORT SEA
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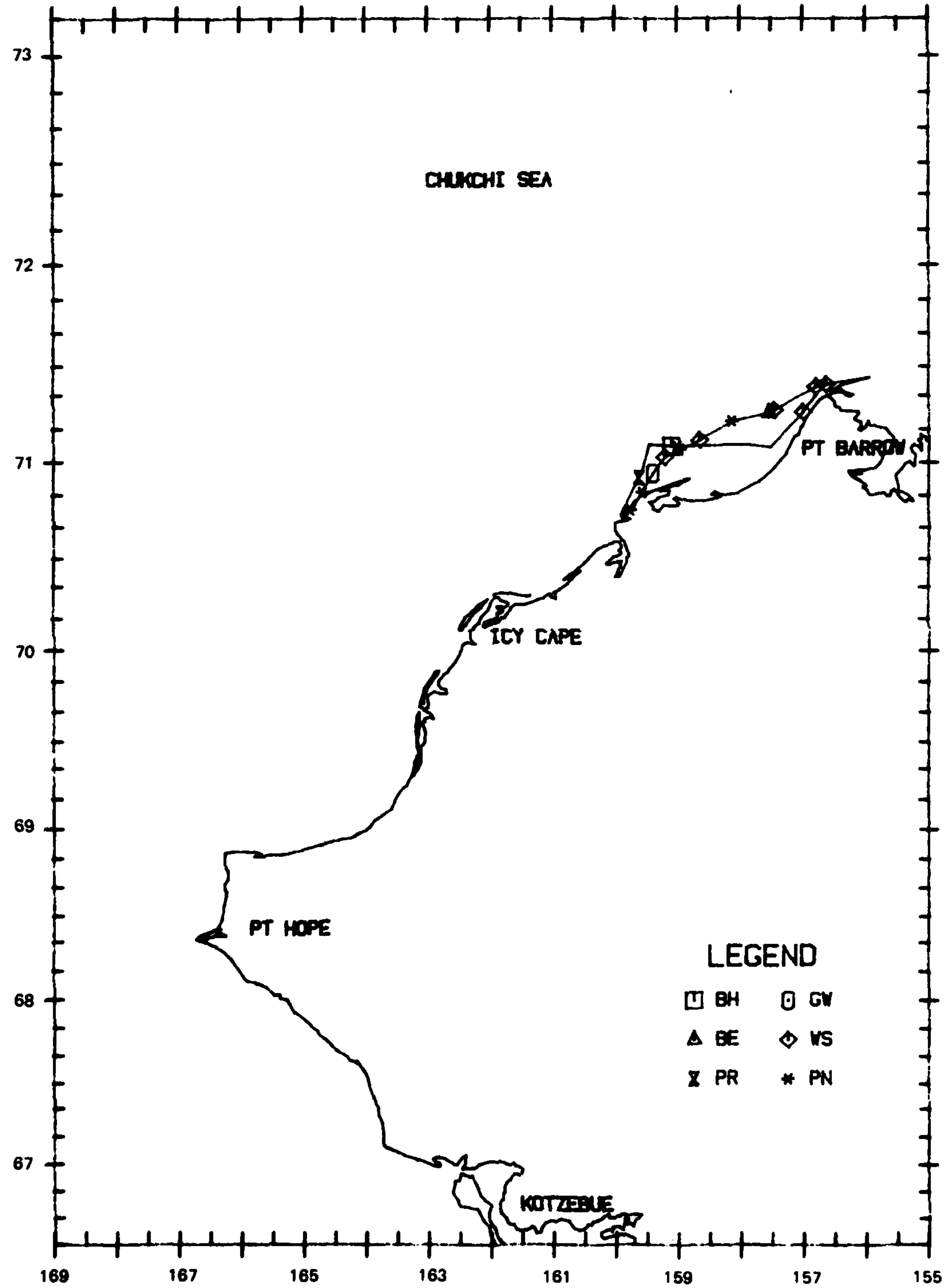
Flight 68: 27 September 1983

Flight was a short search survey in blocks 12 and 13 that was aborted due to icing conditions and unacceptable visibility. Weather was low overcast and visibility ranged from unlimited to unacceptable. Ice coverage was 9/10 in block 13, 2/10 to 9/10 in block 12. Sea state was Beaufort 01. Two bowheads were seen in block 13 swimming slowly south. Two gray whales, belukhas, walruses, polar bears, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	71°05.0'	159°06.3'	394	SP	SW	180	9	B1	37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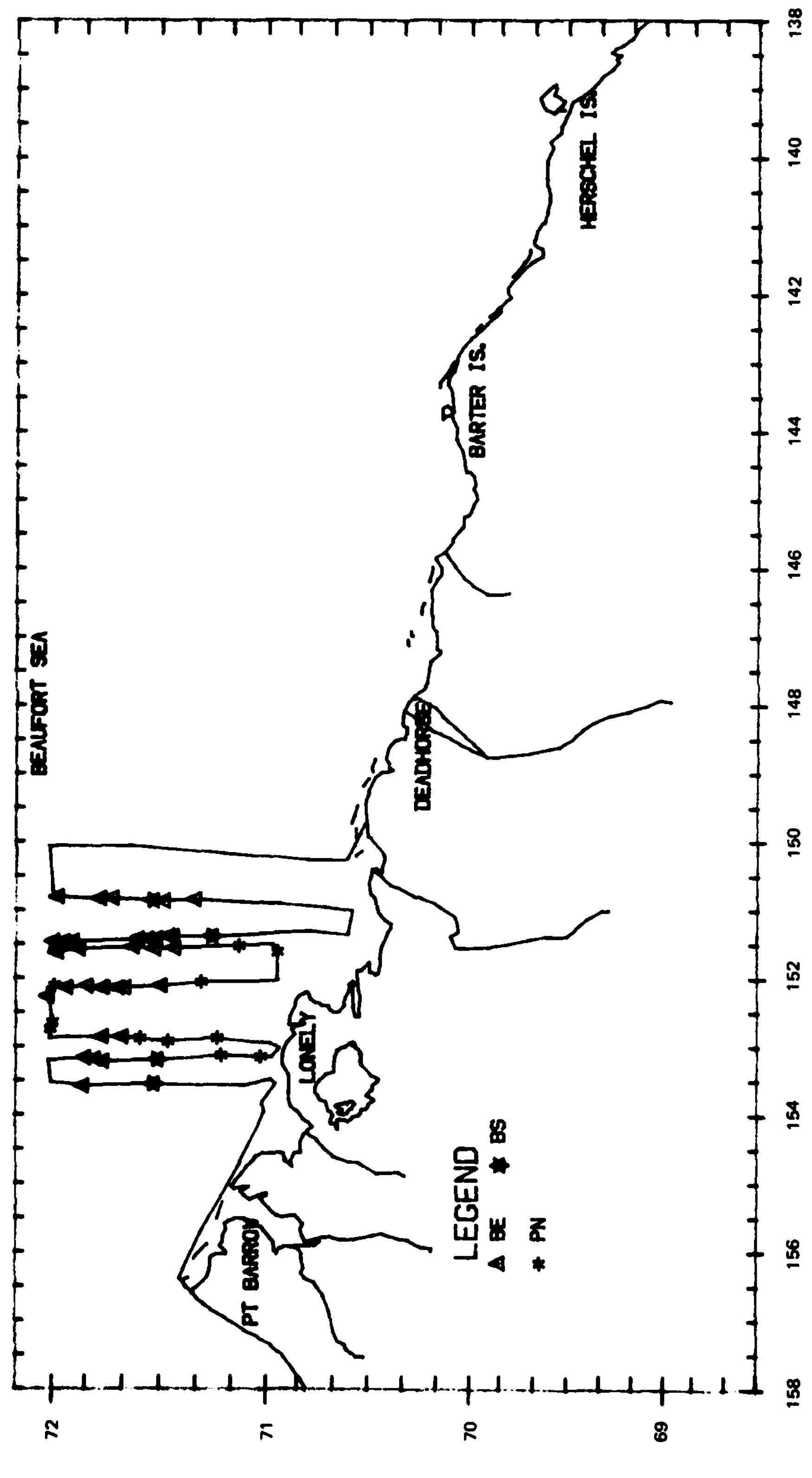
Flight 69: 28 September 1983

Flight was a transect survey of blocks 3 and 11. Weather was clear and visibility unlimited. Ice coverage ranged from 7/10 to 9/10 with much new grease ice. Sea state was Beaufort 01 to 02. Belukhas, bearded seals, and unidentified pinnipeds were seen.



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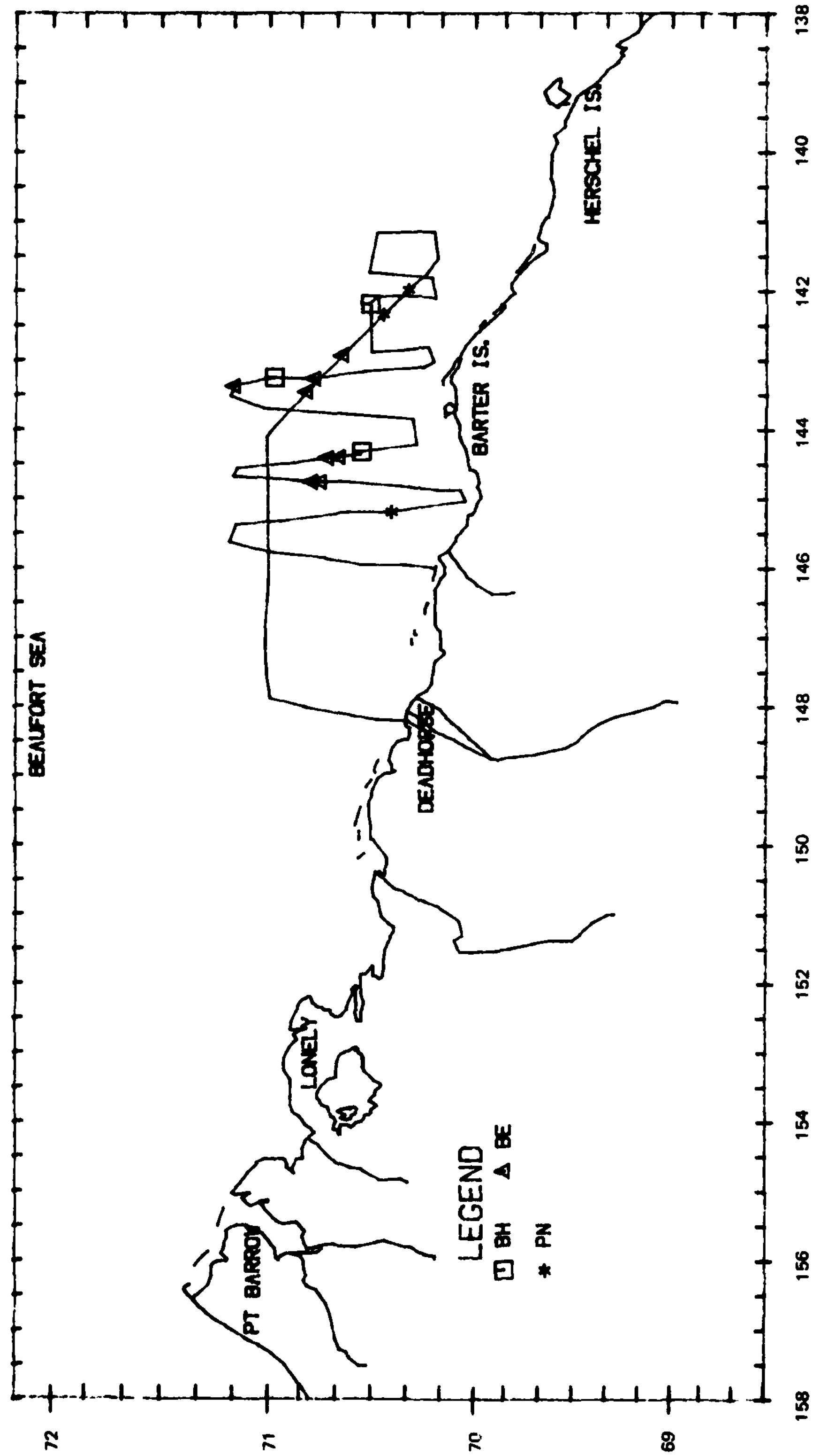
Flight 70: 29 September 1983

Flight was a transect survey in northwest blocks 5 and 4 and all of block 6. Weather was generally clear with heavy nearshore fog causing some legs to be truncated. Visibility was mostly unlimited. Ice coverage ranged from 3/10 to 9/10 and sea state from Beaufort 01 to 05. Five bowheads, belukhas, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°30.6'	142°12.4'	328	BO	RE	330	9	B1	49
2/0	70°57.2'	143°15.9'	185	BO	SW	250	9	B2	366
2/0	70°32.9'	144°20.4'	328	BO	SW	240	8	B4	49



BEAUFORT SEA
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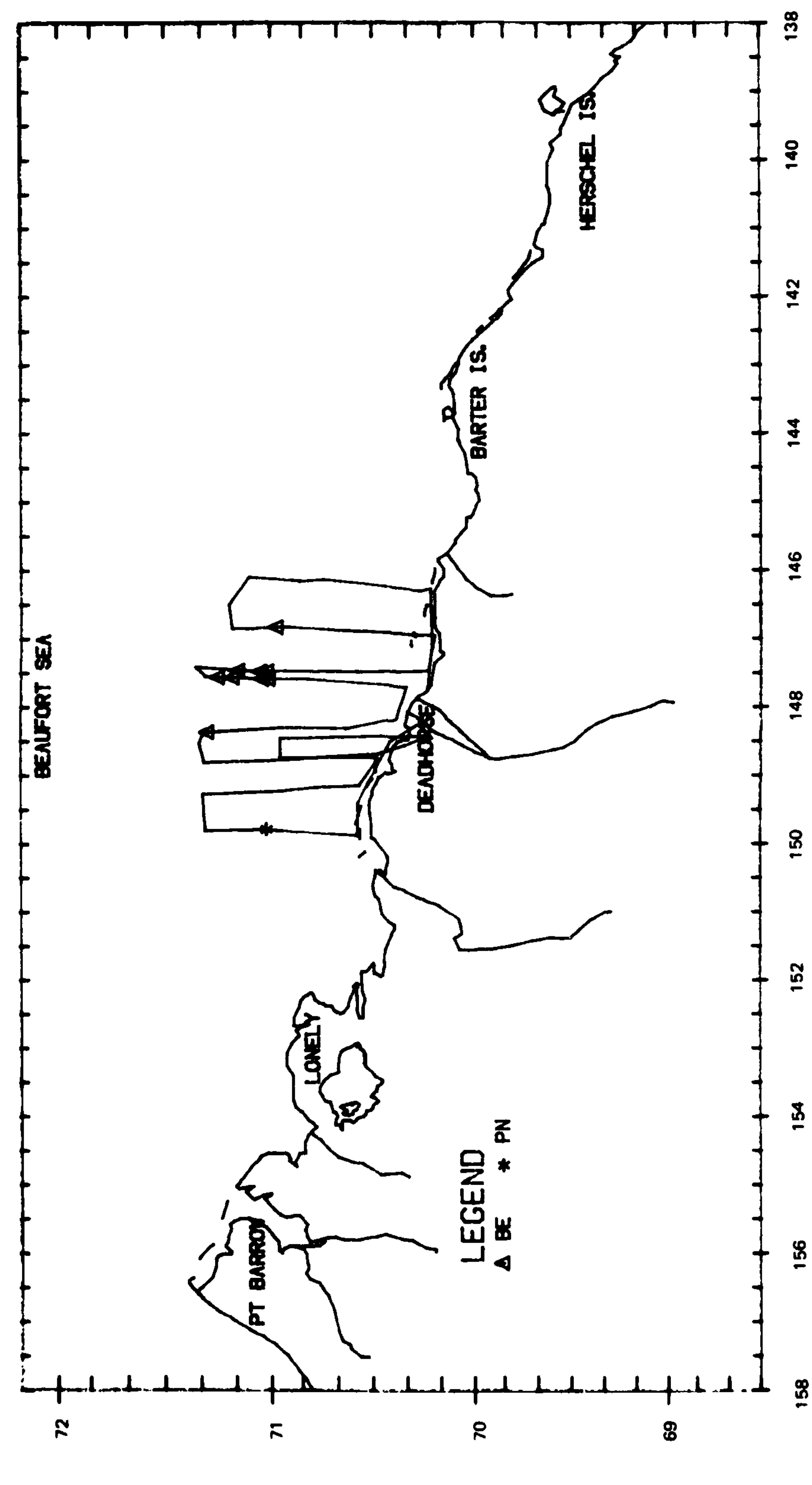
Flight 71: 30 September 1983

Flight was a transect survey in blocks 1 and 2. Weather was overcast with some fog in block 2. Visibility was generally unlimited. Ice coverage ranged from 1/10 to 8/10 and sea state from Beaufort 01 to 04. Belukhas and an unidentified pinniped were seen.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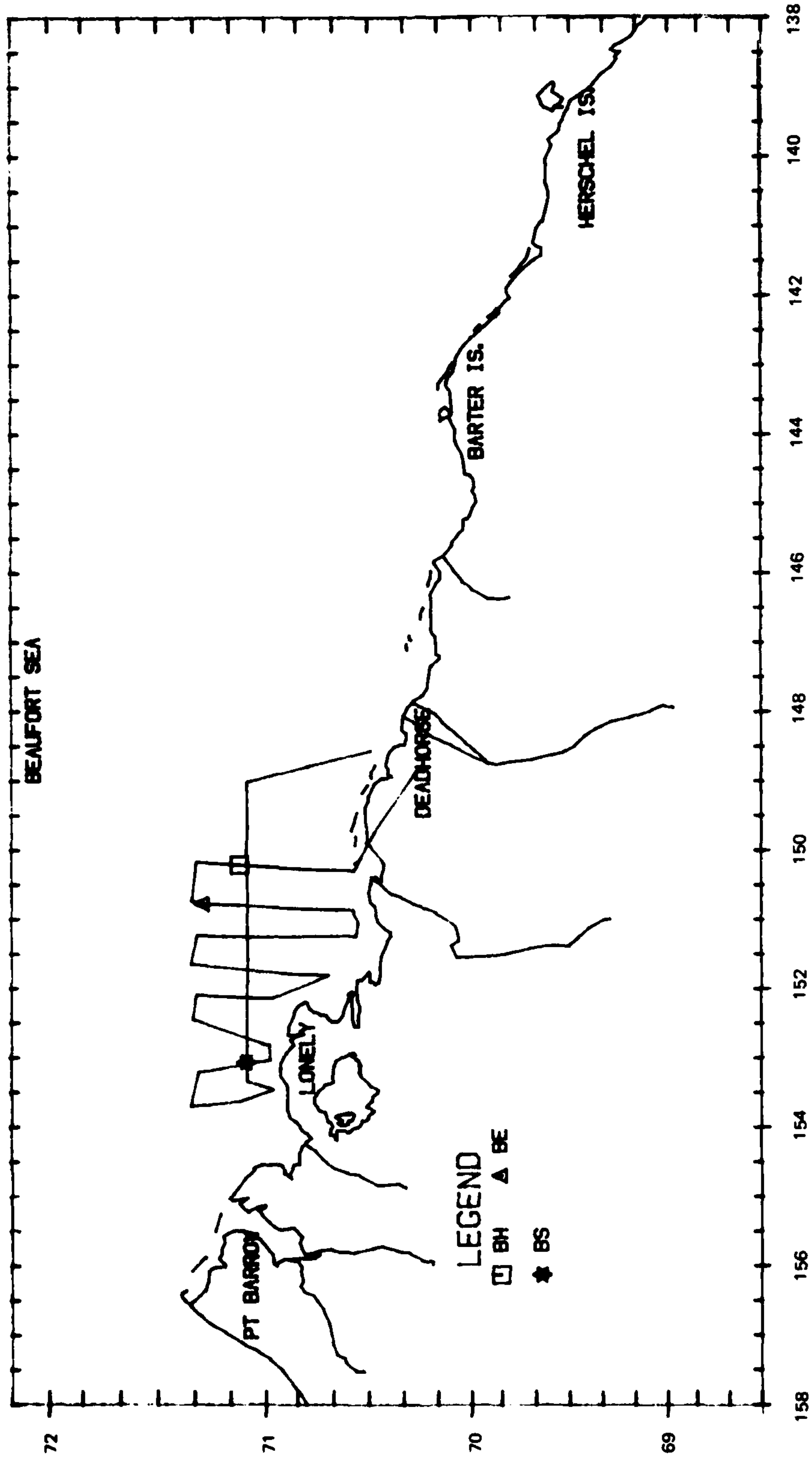
Flight 72: 1 October 1983

Flight was a transect survey in block 3. Weather was partly cloudy and visibility unlimited. Ice coverage ranged from open water to 8/10 and sea state from Beaufort 00 to 02. A bowhead cow-calf pair, belukhas, and a bearded seal were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/1	71°07.0'	150°13.2'	609	BO	SW	240	7	B2	51


BEAUFORT SEA
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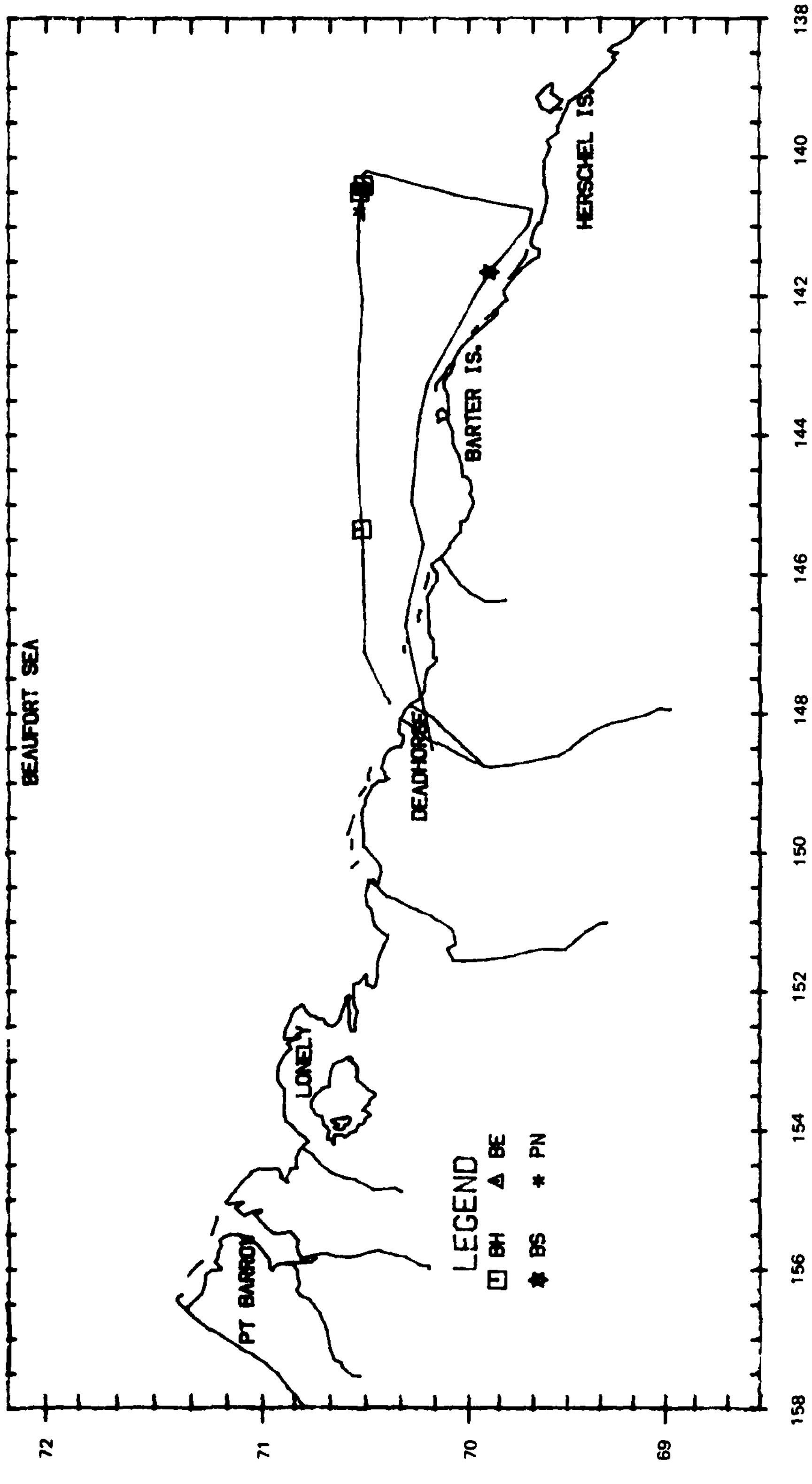
Flight 73: 2 October 1983

Flight was a partial transect, then search survey in block 5. Weather was overcast with areas of fog. Visibility varied from unlimited to unacceptable. Ice coverage ranged from 1/10 to 9/10; sea state was Beaufort 00 to 01. Six bowheads were seen including two cow-calf pairs and one whale tail-slapping. Belukhas, a bearded seal, and an unidentified pinniped were also seen. Two sonobuoys were dropped near the bowhead cow-calf pairs and good calls were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°30.4'	140°24.1'	1996	BO	SW	240	7	B0	600
2/1	70°30.4'	140°24.1'	-	BO	CC	240	9	B0	600
2/1	70°31.5'	140°29.8'	-	BO	CC	240	9	B0	572
1/0	70°30.8'	145°20.9'	-	SP	TS	260	9	B0	46


BEAUFORT SEA
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HERSCHEL IS.
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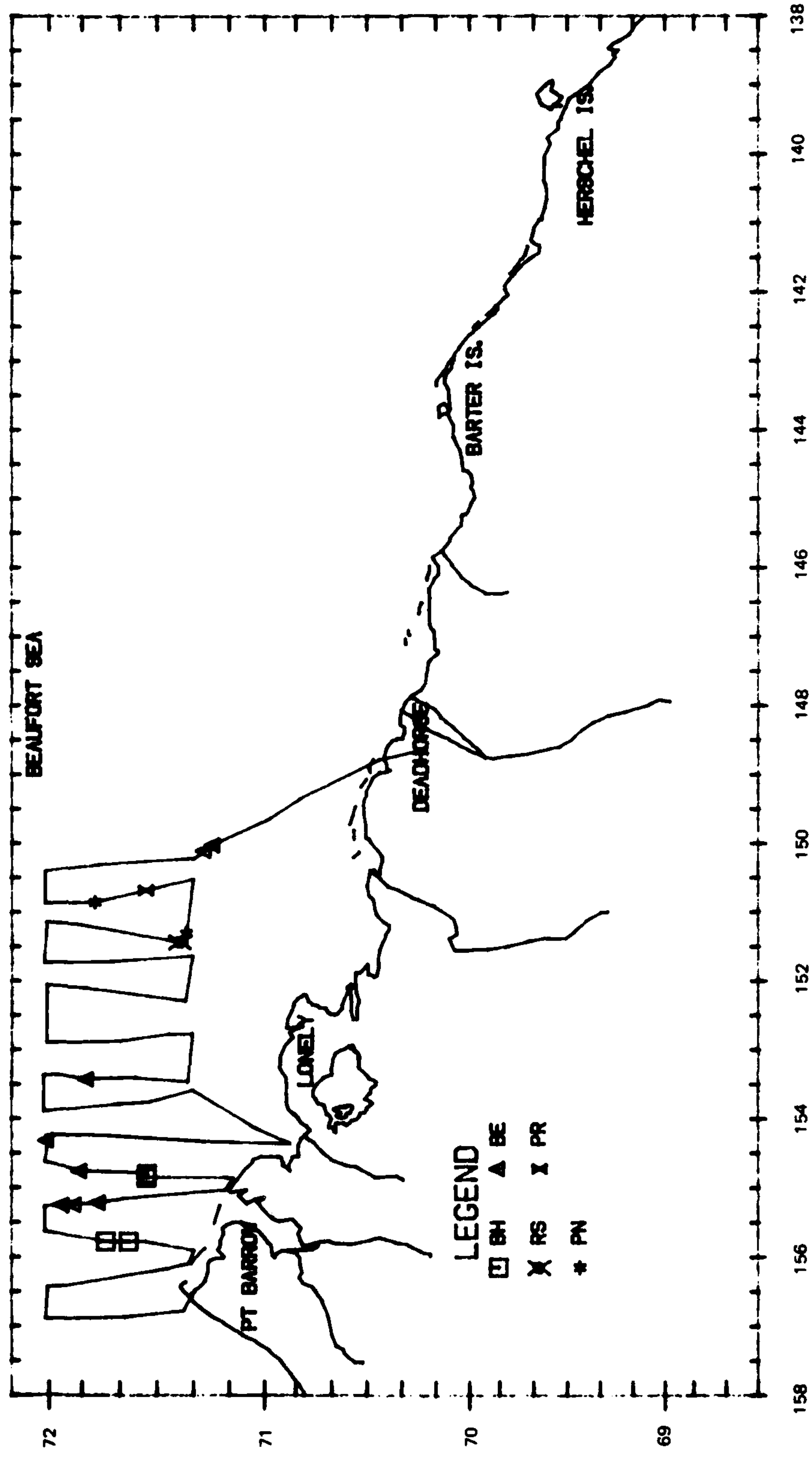
Flight 74: 4 October 1983

Flight was a transect survey of blocks 11 and 12. Weather was partly cloudy with sparse patches of fog. Visibility was generally unlimited. Ice coverage ranged from 1/10 to 9/10 and sea state was from Beaufort 01 and 03. Seven bowheads were seen in block 12, two that appeared brownish on the top of the head and one that seemed brownish overall. Belukhas, a ringed seal, a polar bear, and unidentified pinnipeds were seen. A sonobuoy was dropped, but only ambient noise was recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	71°32.5'	154°47.7'	685	BW	SW	240	1	B3	40
2/0	71°32.6'	154°50.8'	-	BW	SW	240	1	B3	40
2/0	71°43.5'	155°46.2'	1104	BW	SW	240	4	B2	126
1/0	71°37.4'	155°46.3'	718	BW	SW	360	4	B2	199


BEAUFORT SEA
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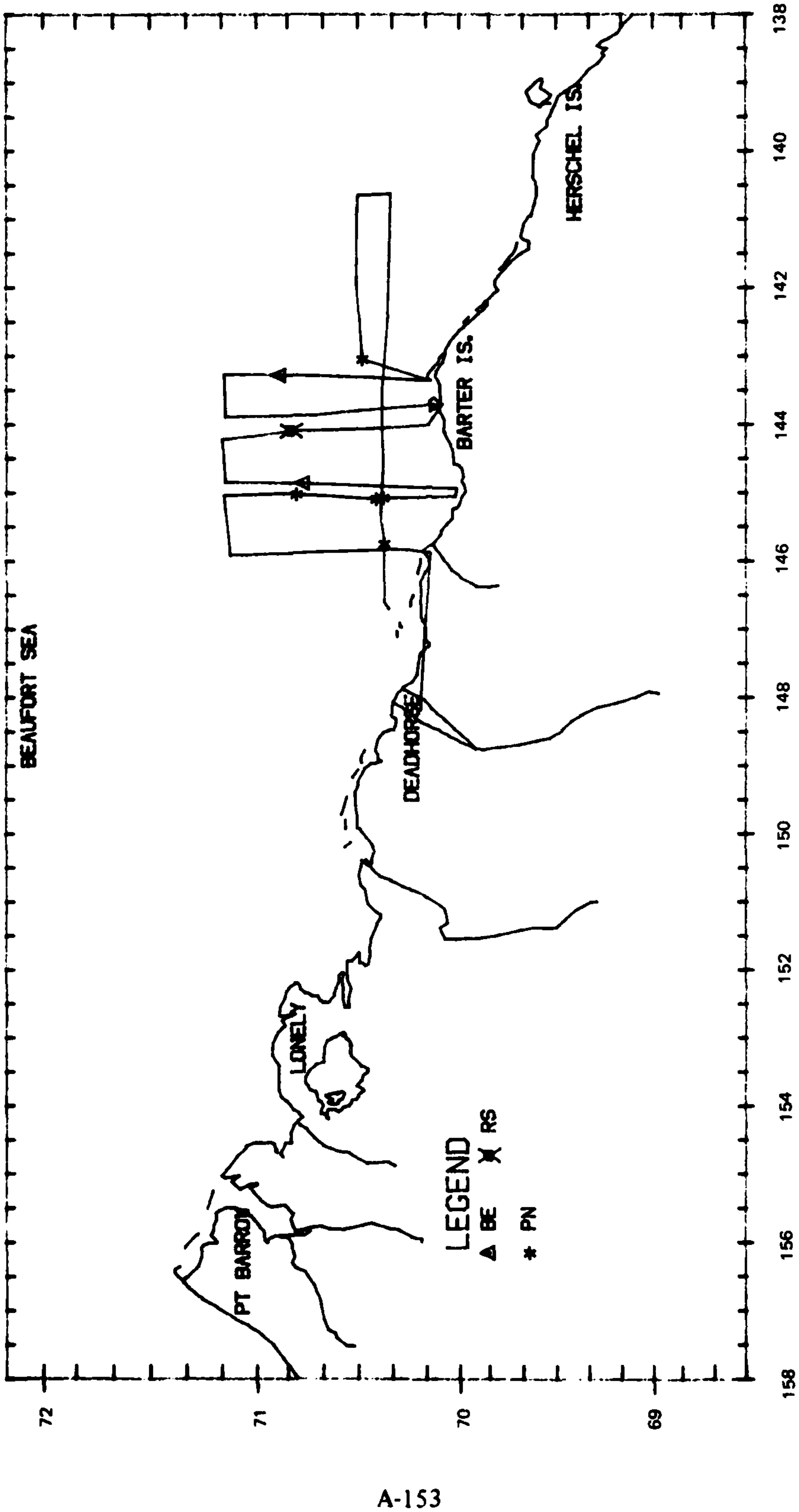
Flight 75: 5 October 1983

Flight was a transect survey of blocks 4 and 6 with a search survey along 70°30'N and 70°20'N in block 5. Weather was overcast with snow squalls and patches of fog. Visibility ranged from unacceptable to unlimited. Ice coverage was open water to 9/10 and sea state Beaufort 00 to 01. Belukhas, a ringed seal, and unidentified pinnipeds were seen.



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Flight 76: 7 October 1983

Flight was a transect survey of blocks 1, 2, and part of 10. Weather was overcast with generally unlimited visibility. The ice coverage was mostly 5/10 broken floe and new ice with sea state Beaufort 03. Belukhas, polar bears, bearded seals, and unidentified pinnipeds were seen.

AD-A146 373 AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING EASTERN CHUKCHI..(U) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA D K LJUNGBLAD ET AL. JUN 84 NOSC/TR-955 4/4

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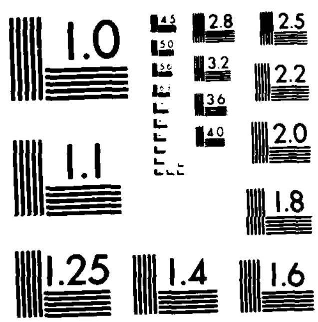

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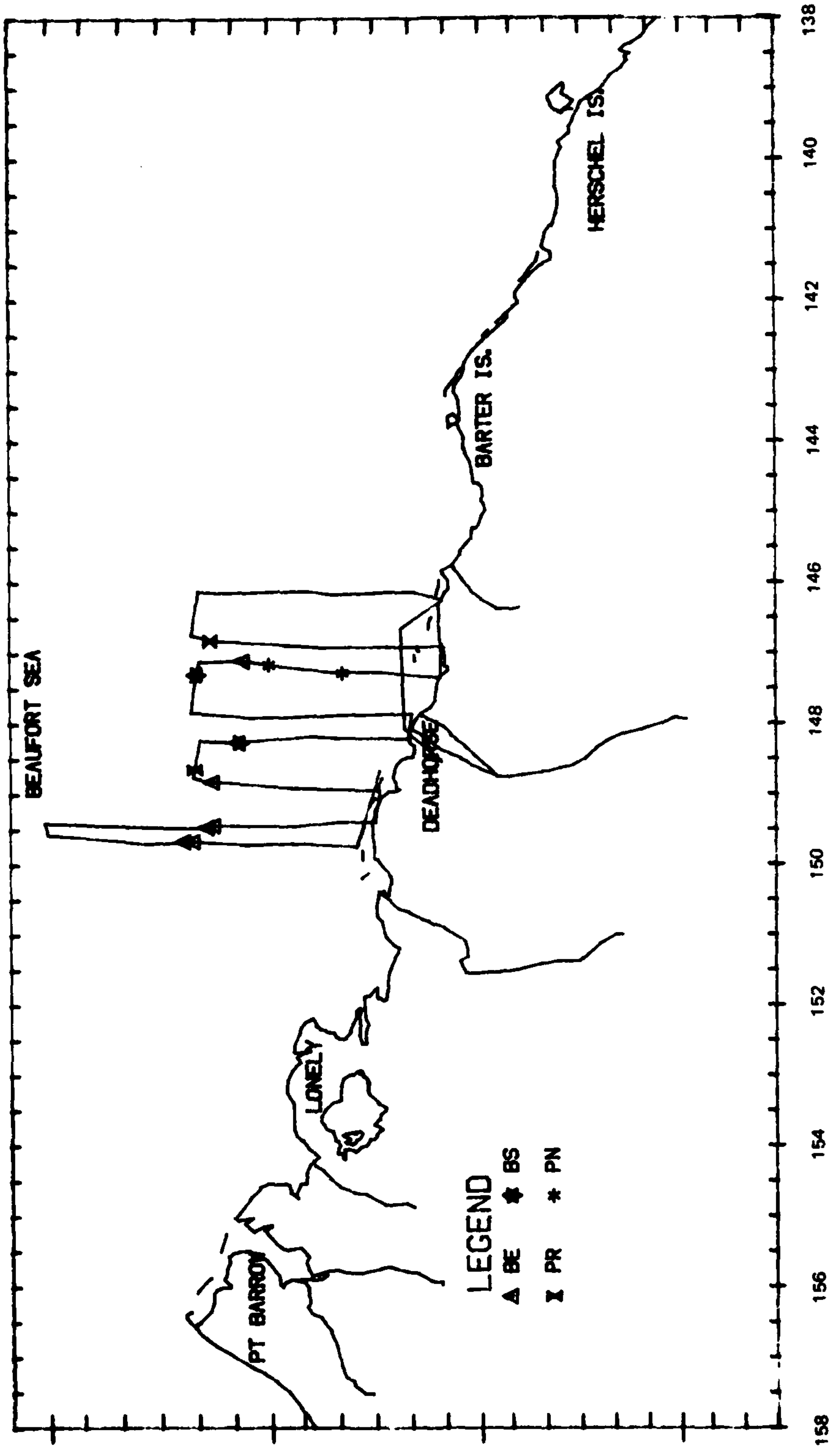
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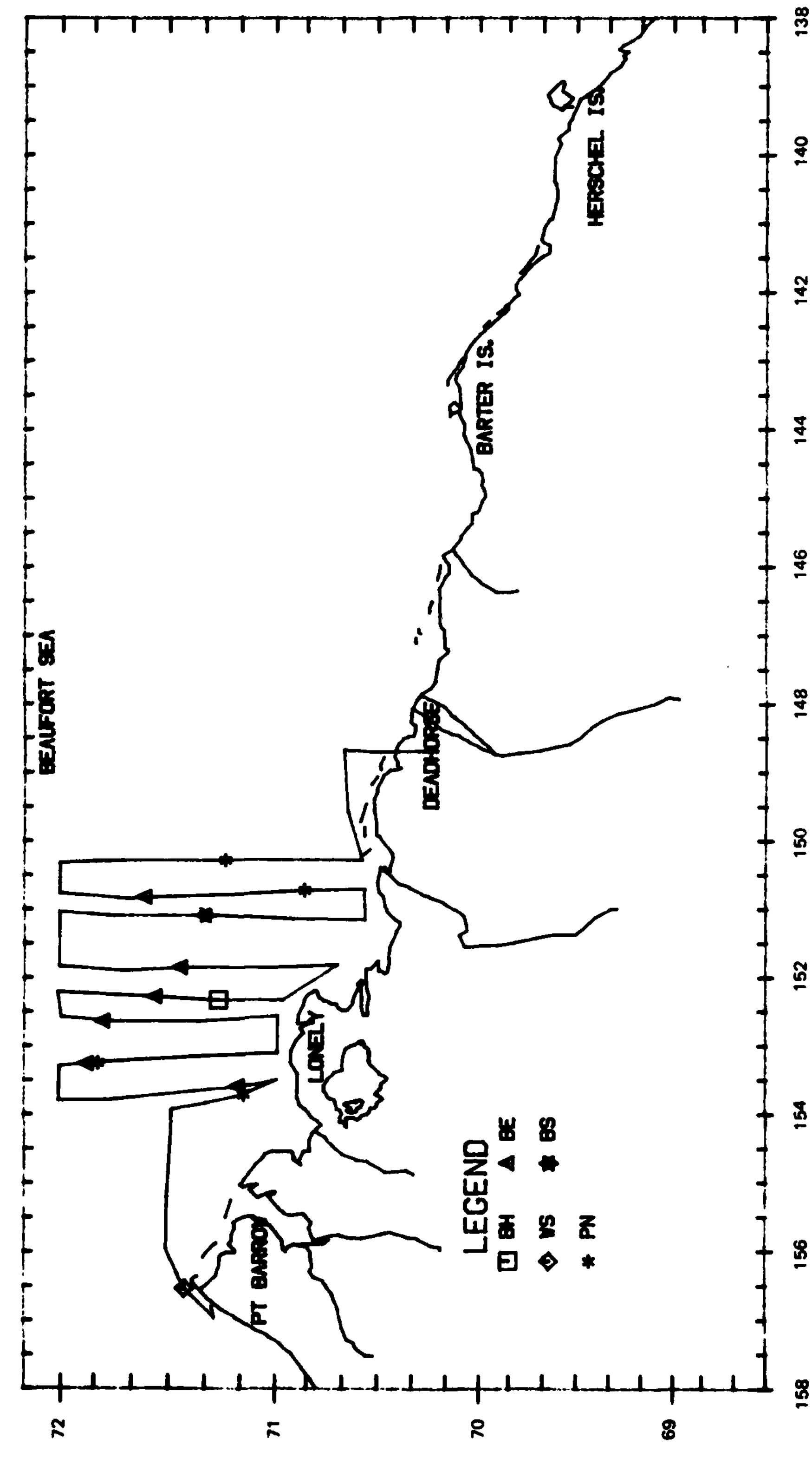
Flight 77: 8 October 1983

Flight was a transect survey of blocks 3 and 11. Weather was clear in the southern half and overcast in the northern half of the survey blocks with unlimited visibility. The ice coverage was generally 9/10 of broken floe and new ice with a sea state Beaufort 00 to 01. One bowhead was seen swimming slowly west north of Cape Halkett. Belukhas, bearded seals, walruses, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°16.1'	152°19.8'	137	BO	FE	240	8	B0	48


BEAUFORT SEA
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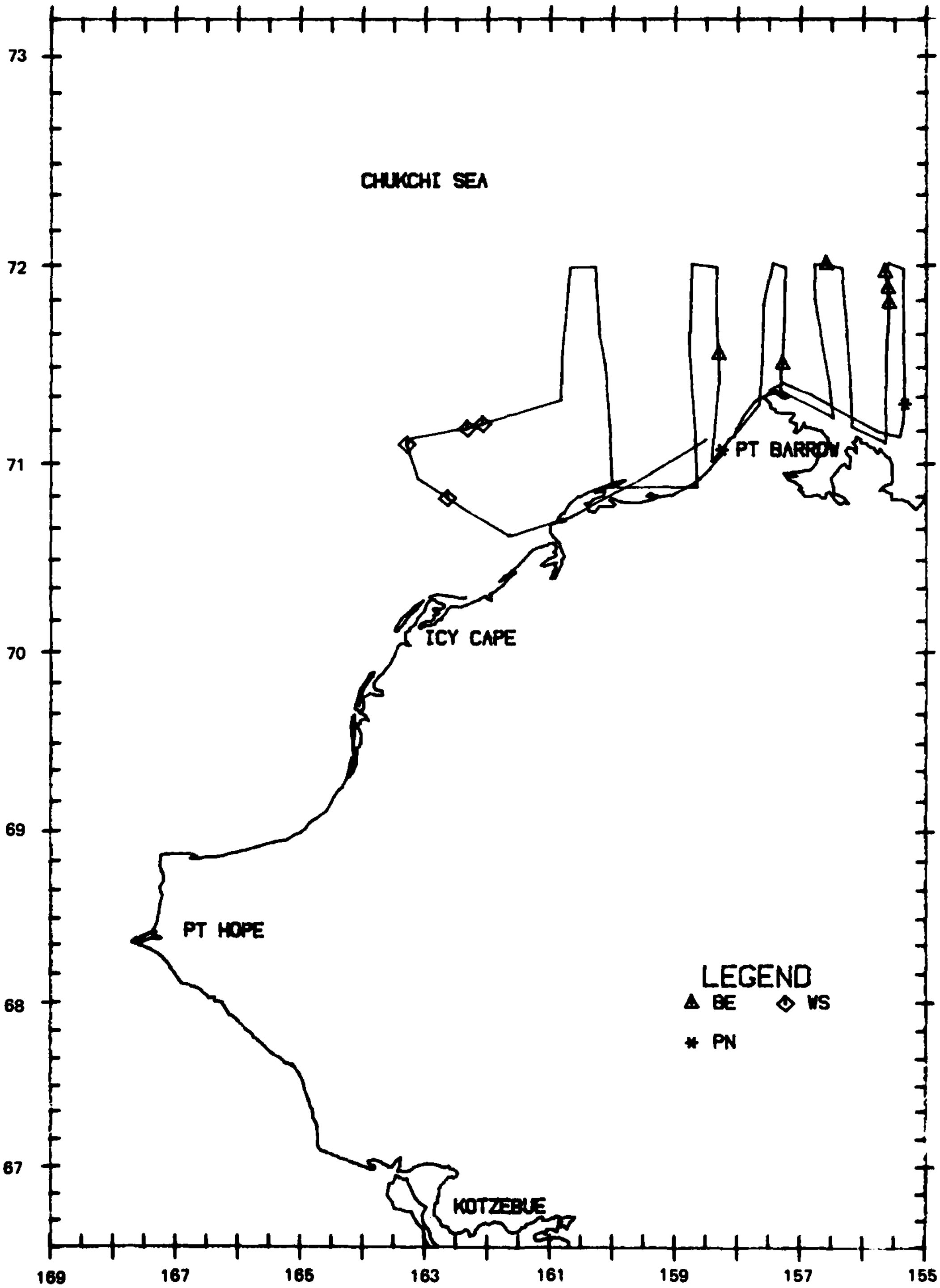
Flight 78: 10 October 1983

Flight was a transect survey of blocks 12 and 13. Weather was low overcast in the south and clear in the north. Visibility was generally unlimited. Ice coverage was 9/10 broken floe and new ice except for a 50 km wide coastal strip of open water. Sea state ranged as high as Beaufort 05 in the open water. Belukhas, walruses, and unidentified pinnipeds were seen. A sonobuoy was dropped but no sounds were recorded.



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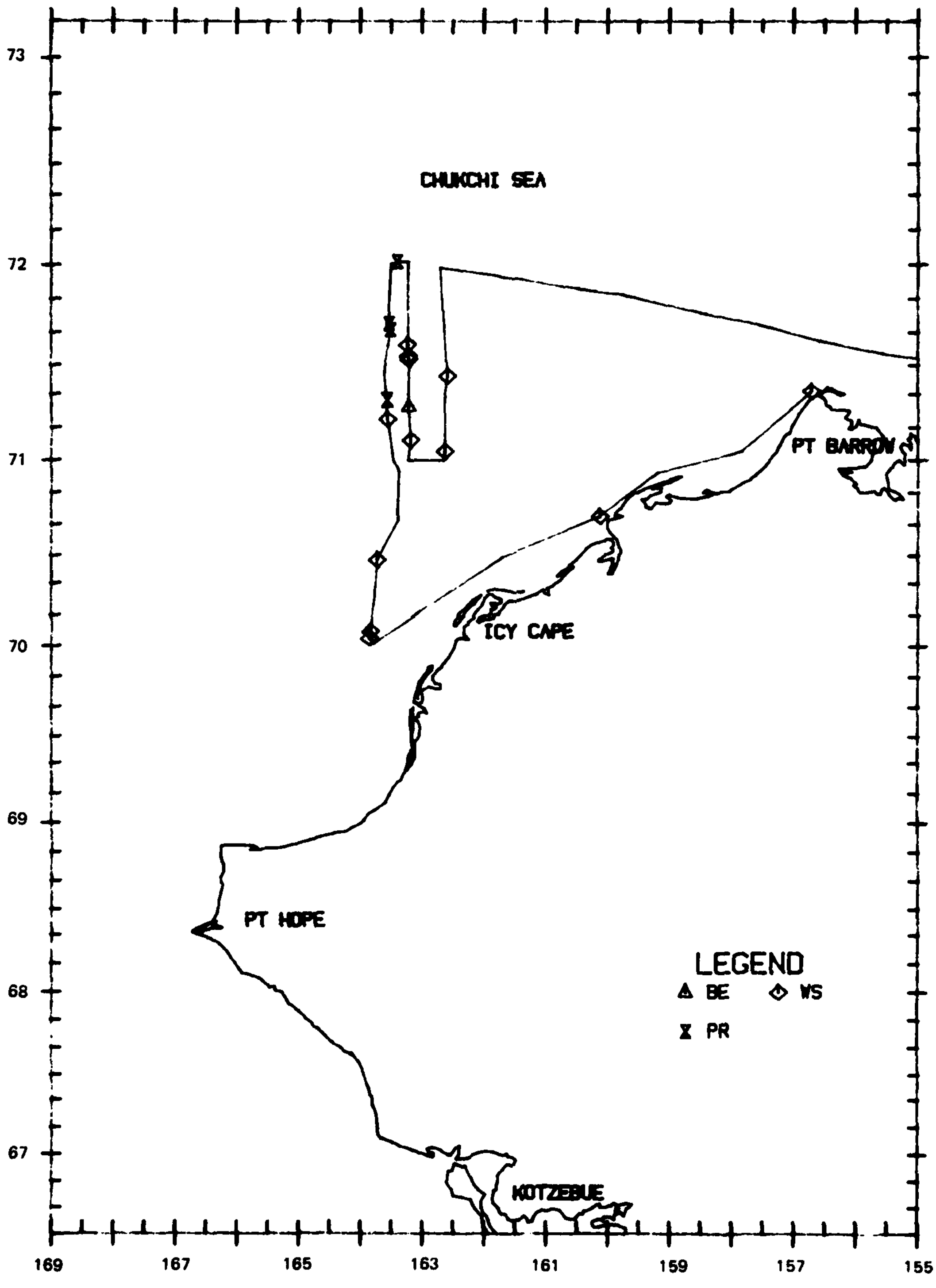
Flight 79: 11 October 1983

Flight was a transect survey of block 14 after attempting block 17, and a transit to Deadhorse. Weather was overcast and visibility was generally unlimited. Ice coverage was 9/10 broken floe and new ice to the north, with open water in the 30 km wide near shore lead. Sea state was Beaufort 02 in the ice and up to Beaufort 06 in the open water. Belukhas, walruses, and polar bears were seen.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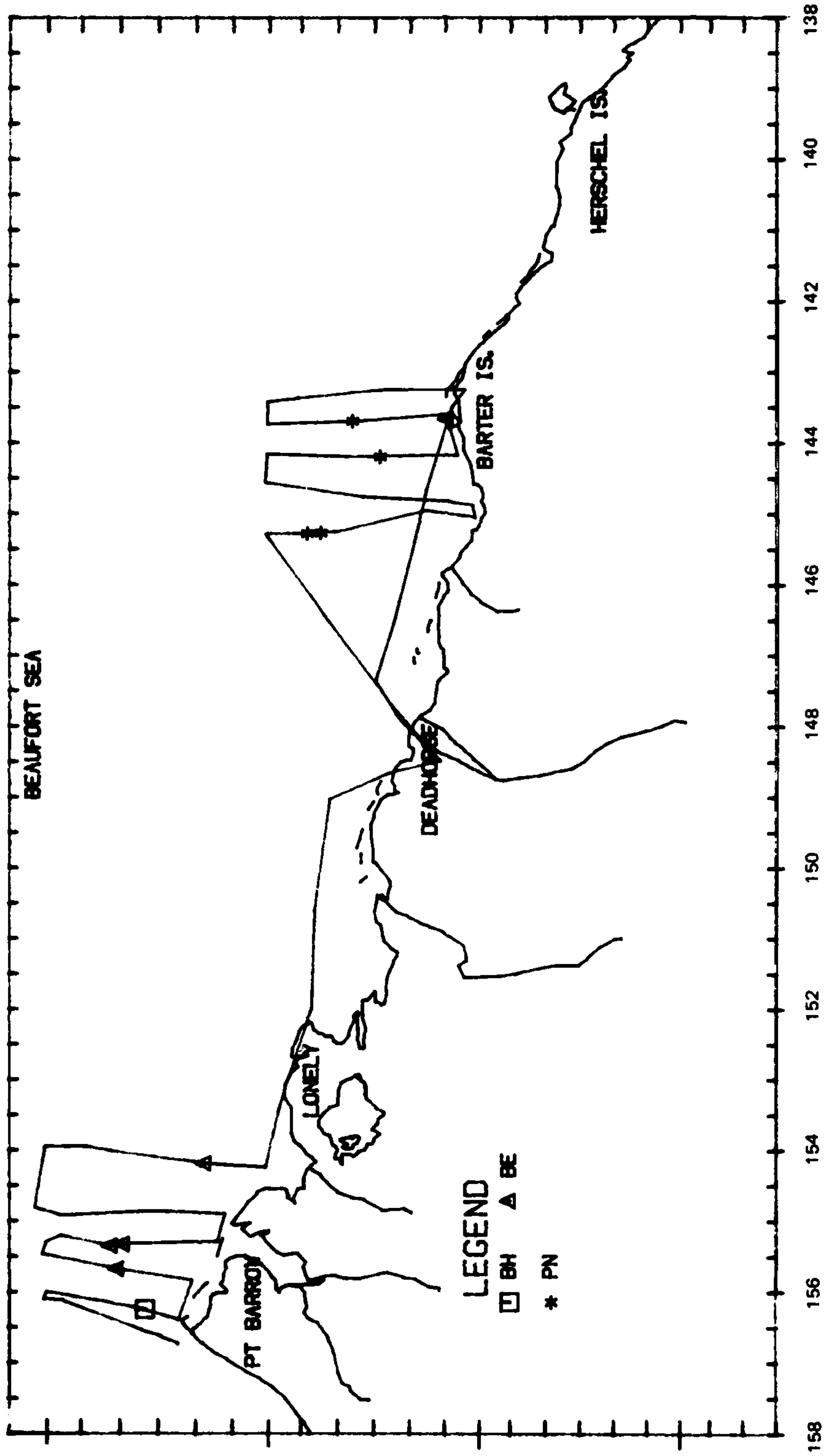
Flight 80: 12 October 1983

Flight was a transect survey of blocks 4, 6, and 12. Weather was overcast and visibility unlimited. Ice coverage was 9/10 of broken floe and there was new ice with all new ice near shore. Sea state was Beaufort 01 to 02. One bowhead was seen swimming west north of Pt. Barrow. Belukhas and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°33.4'	156°15.5'	390	BO	SW	260	8	B1	165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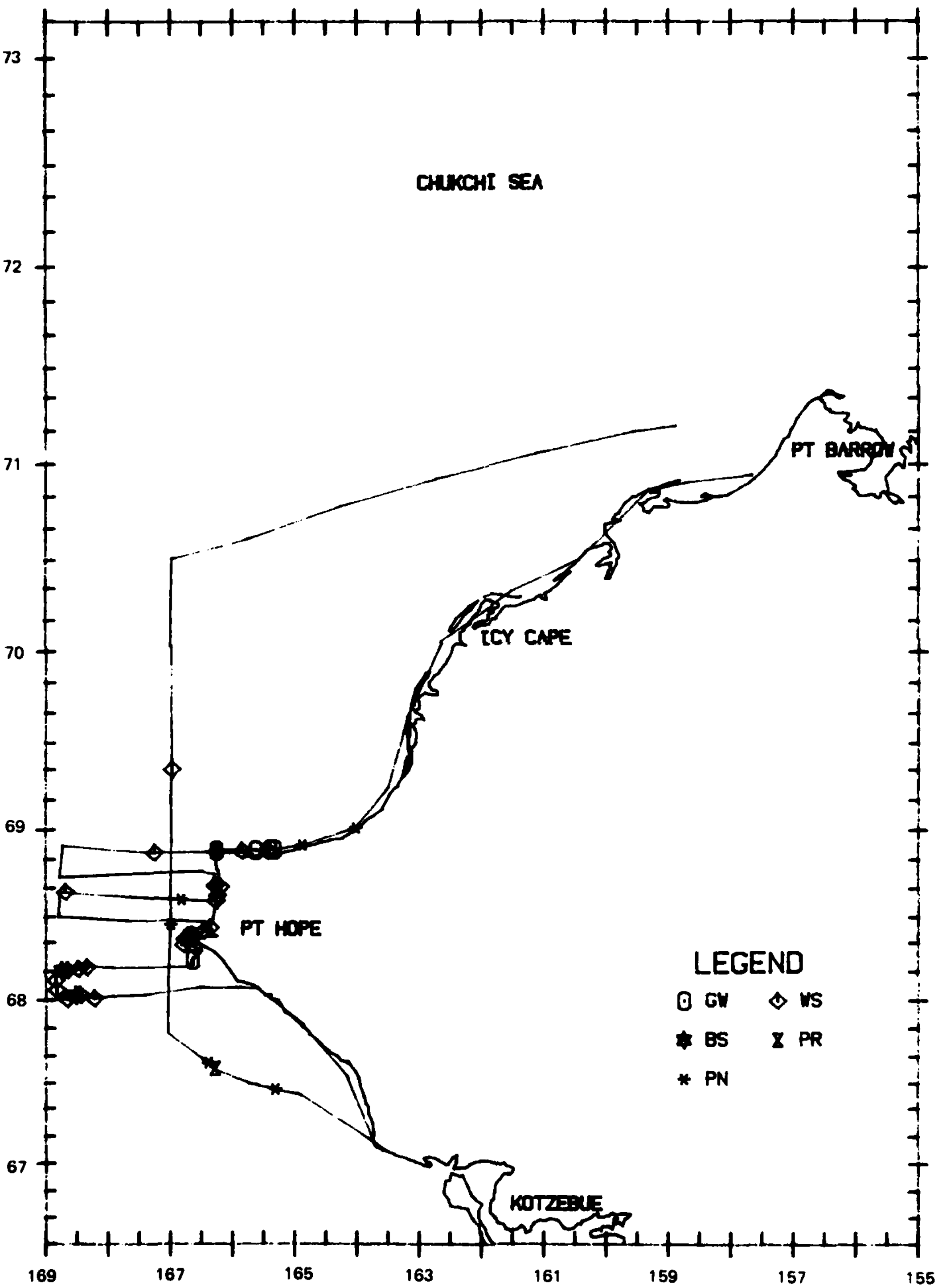
Flight 81: 13 October 1983

Flight was a transect survey of block 22 with a refueling stop at Kotzebue and a search survey back to Pt. Barrow. Weather was overcast with unlimited visibility. Ice coverage was 9/10 broken floe in the southwest corner of the block; otherwise the area had open water with a Beaufort 03 sea state. Ten gray whales were seen along the coast. Walruses were seen along the coast and in the ice, polar bears were seen in outer Kotzebue Sound, and bearded seals and unidentified pinnipeds were seen throughout. A sonobuoy was dropped near the gray whales, but only ambient noise was recorded.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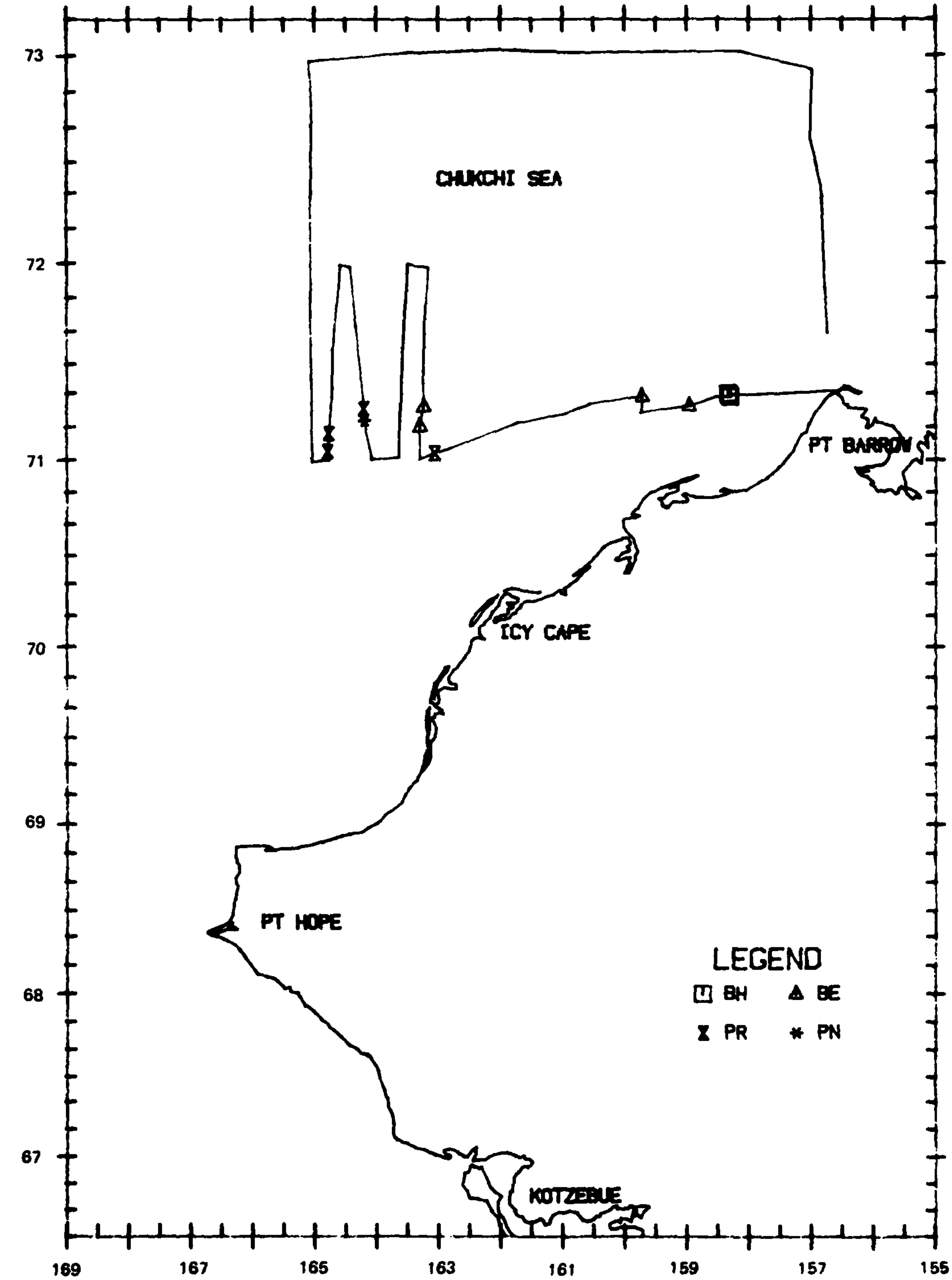
Flight 82: 14 October 1983

Flight was a transect survey of block 15 and an ice reconnaissance survey along the 73°N line. Weather was overcast with unlimited visibility. Ice coverage was 9/10 mostly new ice south of 72°N, and 10/10 along the 73°N line. Sea state was Beaufort 01 to 04. Three bowheads were seen west of Pt. Barrow along the ice edge. One was tail-slapping. Belukhas, polar bears, and pinnipeds were also seen. One sonobuoy was dropped and a few bowhead sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	71°19.8'	158°20.0'	-	BO	SW	210	0	B4	49
1/0	71°19.5'	158°18.9'	-	BO	TS	210	0	B4	49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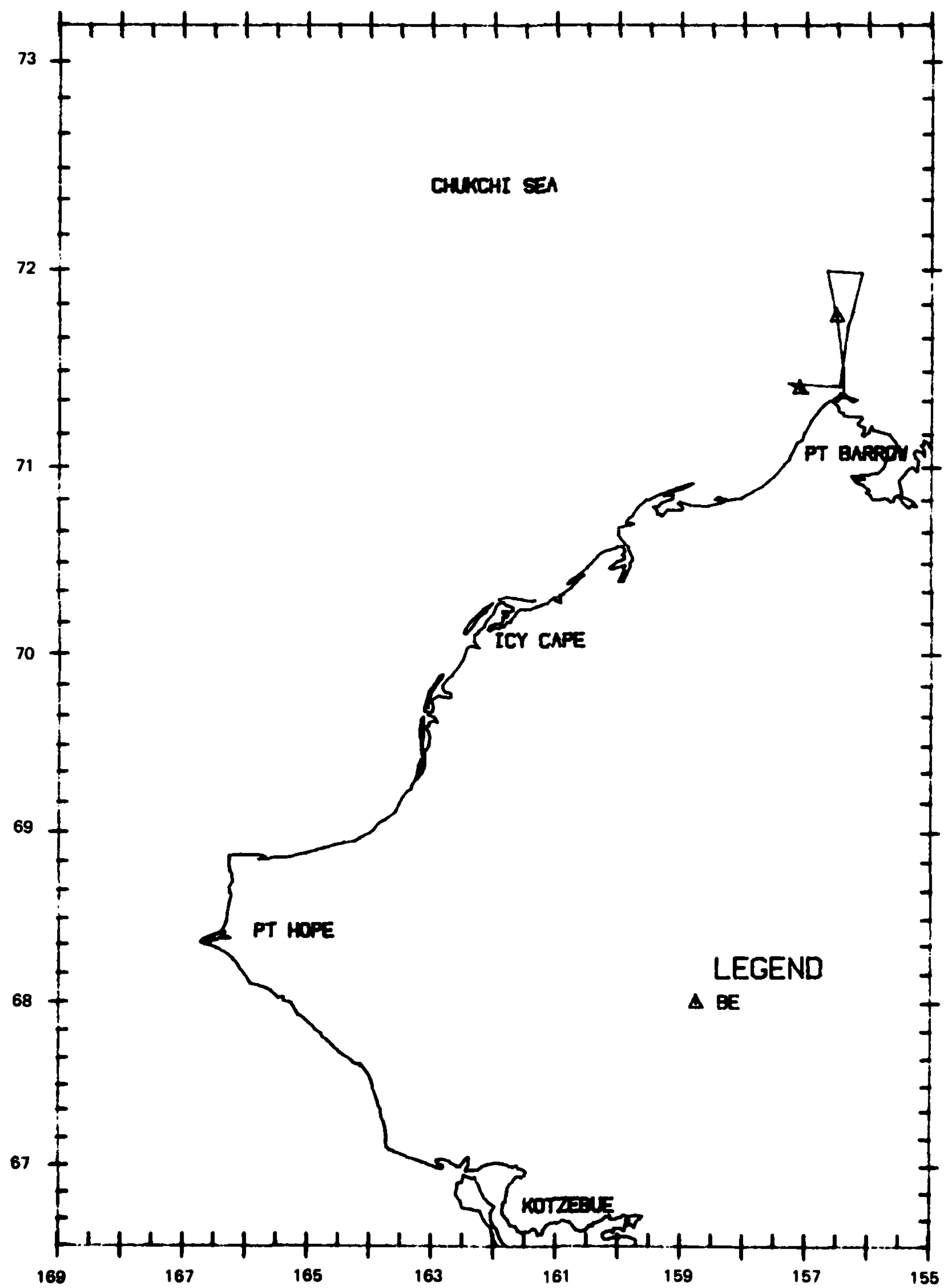
Flight 83: 15 October 1983

Flight was a transect survey of block 17. Weather was overcast with snow flurries. Visibility was 3 to 5 km. Ice coverage was 9/10 new ice along the northeast corner of the block and 10/10 floe along the northwest corner. Sea state was Beaufort 02 to 04 in the open water to the south. Four swimming bowheads were seen southwest of Pt. Barrow. Belukhas, walruses, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°53.1'	160°56.3'	1434	BO	SW	210	9	B2	44
1/0	70°56.0'	160°40.0'	-	BO	SW	210	0	B3	44
1/0	71°20.6'	157°51.5'	-	BO	DI	-	0	B2	77
1/0	70°55.2'	160°41.9'	-	BO	SW	-	0	B3	44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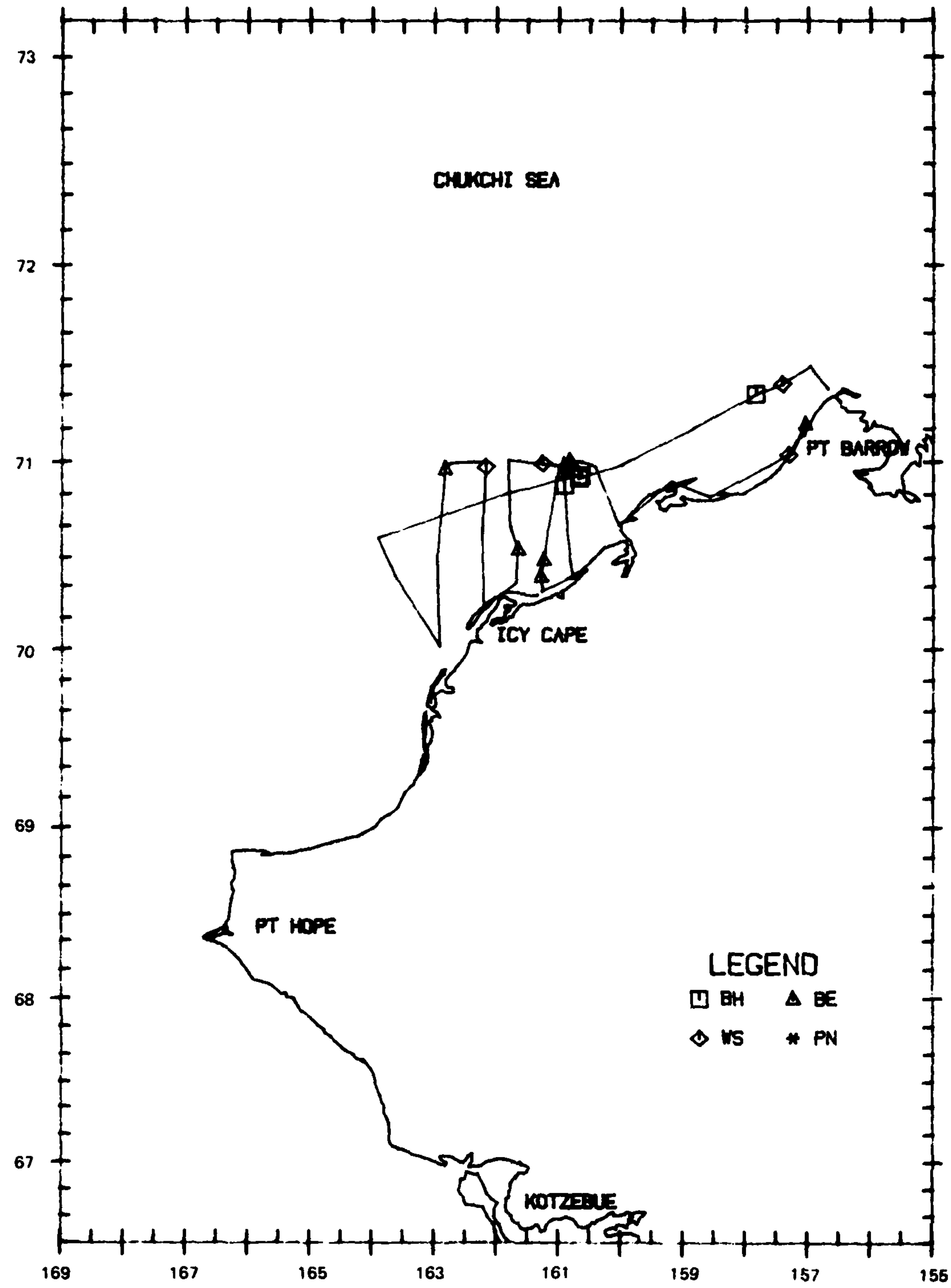
Flight 85: 17 October 1983

Flight was a transect survey of block 18. Weather was overcast with unlimited visibility over the ice in the northern half of the block, with patchy fog and 3 to 5 km visibility over the open water southern section. Ice coverage in the north was 9/10 floe and new ice. Sea state was Beaufort 03 in the open water section and Beaufort 01 in the ice. Six bowheads, including one calf, were seen west of Pt. Barrow. Belukhas, polar bears, walruses, bearded seals. and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°14.9'	158°39.0'	685	BO	FE	120	8	B1	46
2/0	71°14.8'	158°45.0'	582	BO	FE	240	8	B1	46
1/0	71°14.1'	158°44.0'	-	BO	FE	240	8	B1	46
2/1	70°44.6'	163°53.7'	2495	BO	CC	320	9	B0	37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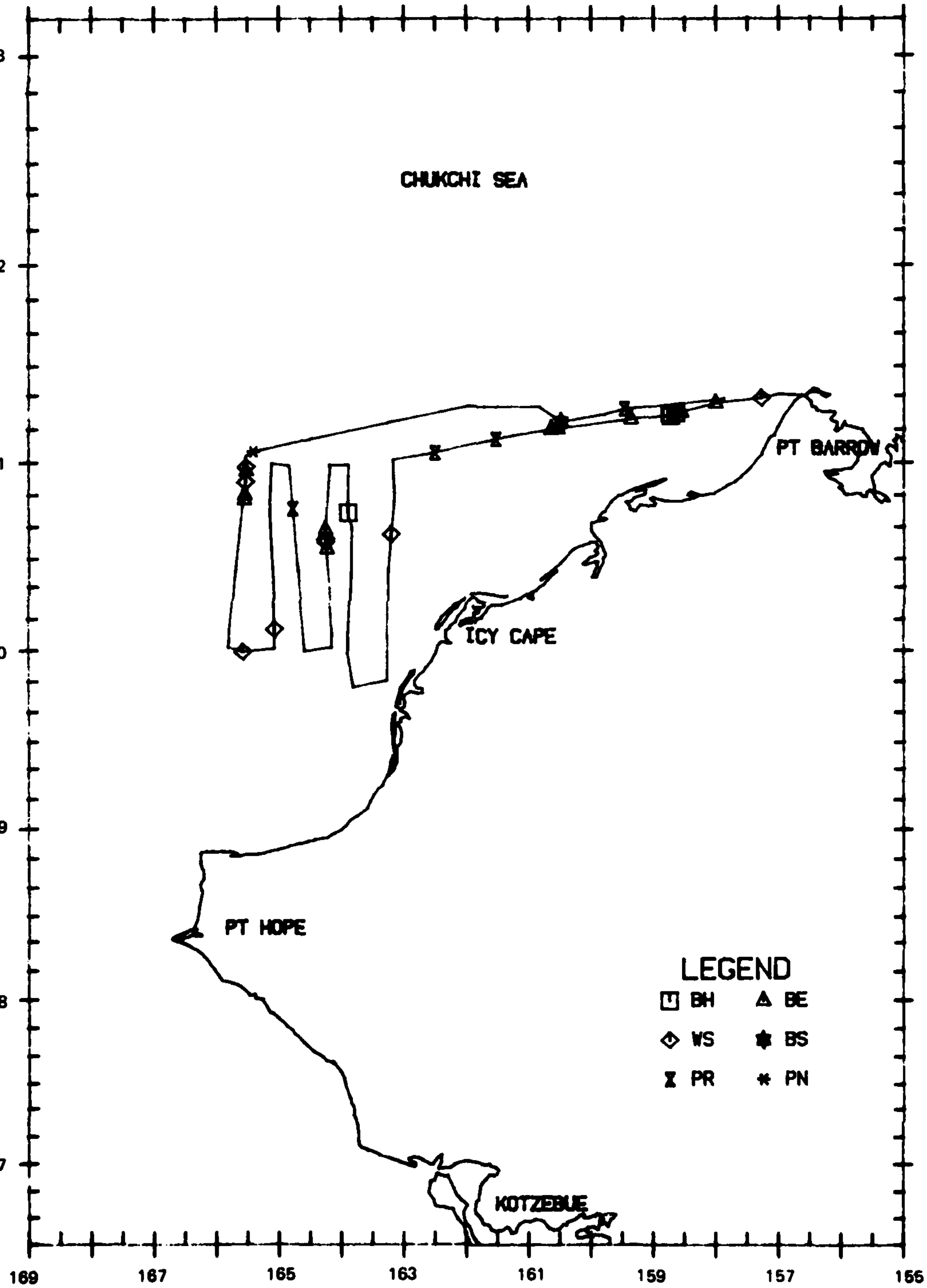
Flight 84: 16 October 1983

Flight was a transect survey of block 12 which was aborted after two legs due to poor weather and visibility. Weather was low overcast with patchy fog and icing. Visibility was generally 3 to 5 km. Ice coverage was greater than 9/10 pack, floe, new, and grease ice. Sea state in the cracks was Beaufort 00. Belukhas were seen.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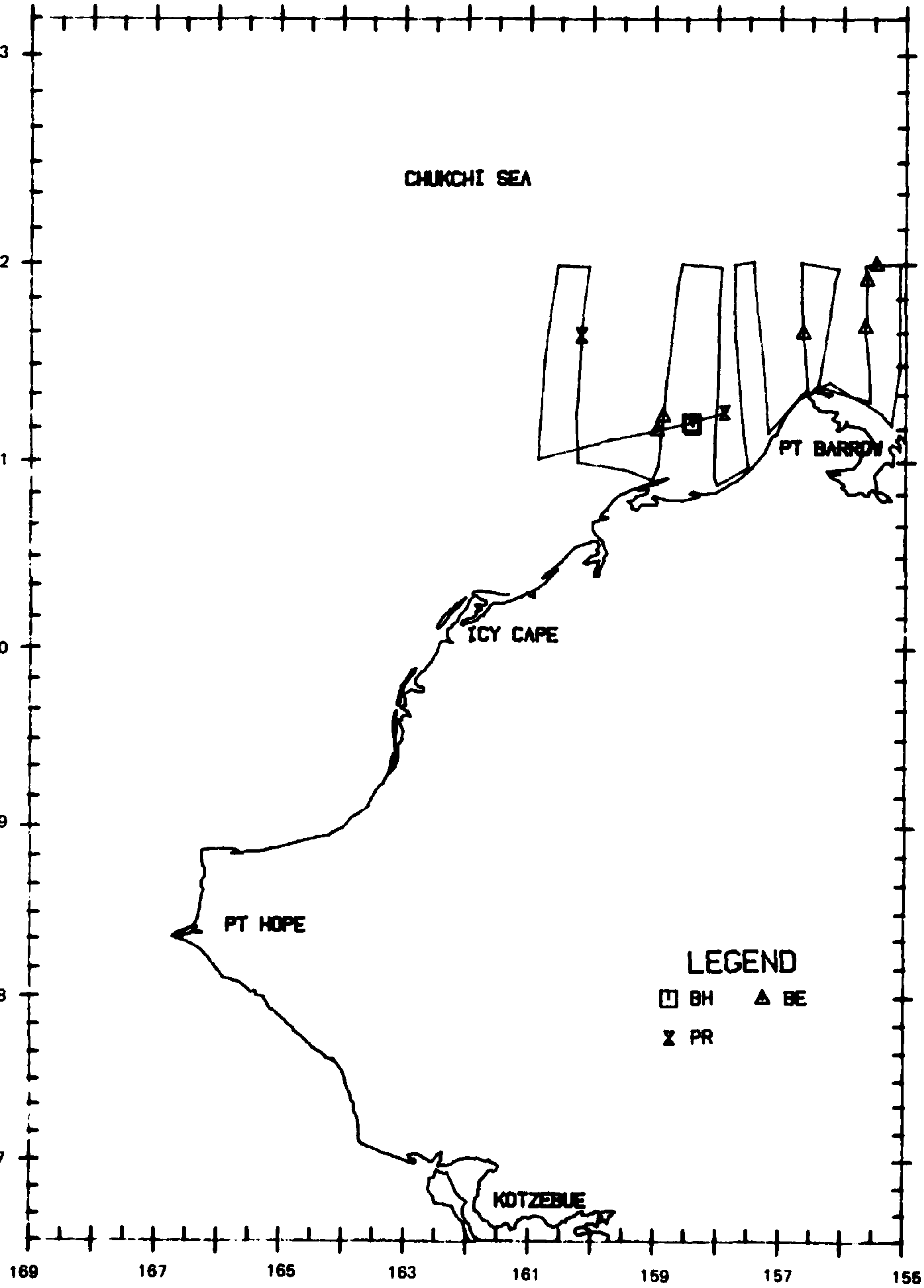
Flight 86: 19 October 1983

Flight was a transect survey of portions of blocks 12, 13, and 14. Weather was clear with unlimited visibility over solid floe ice in block 12. Over the 9/10 ice in blocks 13 and 14 weather was patchy fog with 3 to 5 km visibility. Sea state was Beaufort 01 in the ice and up to Beaufort 03 in open water areas. Five bowheads were sighted milling and possibly feeding west of Pt. Barrow. Belukhas and polar bears were also seen.

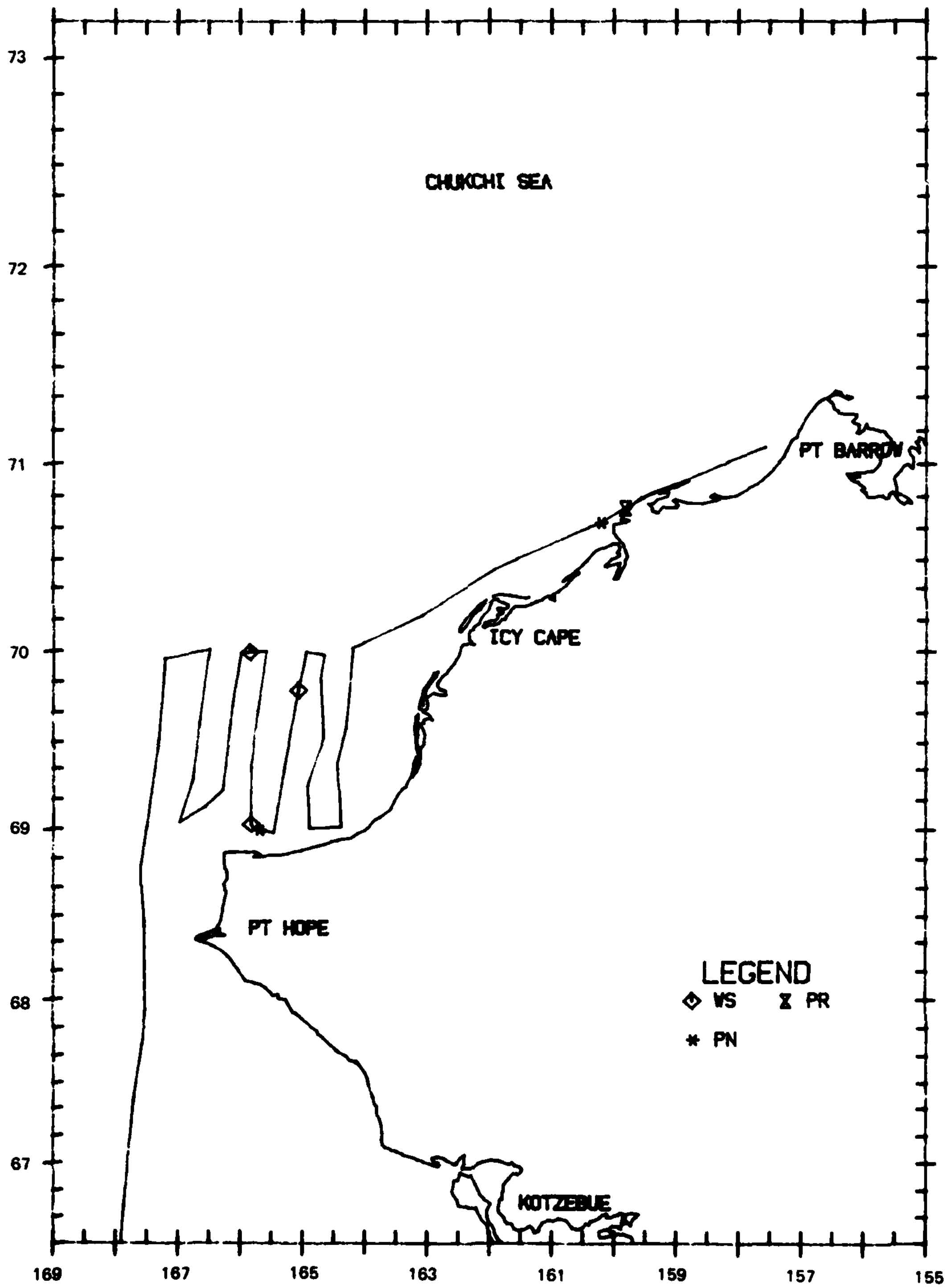
T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	71°12.0'	158°26.4'	-	BO	FE	-	7	B2	46
1/0	71°11.2'	158°24.7'	-	BO	FE	-	7	B3	46
1/0	71°12.1'	158°25.0'	-	BO	FE	300	7	B3	46



CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
KOTZEBUE
LEGEND
BH
BE
PR
73
72
71
70
69
68
67
169
167
165
163
161
159
157
155

Flight 87: 19 October 1983

Flight was a transect survey of blocks 20 and 21 and a transit to Nome via the Bering Strait. Weather was overcast with patchy fog. Visibility ranged from 2 km to unlimited. The ice coverage was 9/10 new ice only in the southern Chukchi Sea. Sea state was up to Beaufort 05 in open water and Beaufort 01 in the ice. Polar bears, walruses and unidentified pinnipeds were seen.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CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
KOTZEBUE
LEGEND
WS
PR
PN

APPENDIX B

Distribution of 1983 Survey Effort
and
Observed Densities of Bowhead and Gray Whales in the Alaskan Beaufort, Eastern Chukchi, and Northern Bering Seas, with comparisons to 1979 through 1982.

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INTRODUCTION

The following section presents an analysis of aerial survey data collected during 1983 and comparison to similarly analysed data for 1979-1982. The objectives of the analysis were to determine distribution and density of bowhead whales in the Beaufort, Chukchi, and Bering Seas, and distribution and density of gray whales in the Bering and Chukchi Seas. An important component of this analysis was determination of the distribution of survey effort.

The Beaufort Sea was treated as one study area bounded by 141°00'W to 157°00'W longitude and 72°00'N latitude to the coastline. The Bering and Chukchi Seas were treated as a second study area. Both study areas were subdivided for the purpose of more precise illustration of survey effort and density of animals.

Distribution of survey effort and density of bowhead whales in the Beaufort Sea study area were examined during spring (April-May) and fall (August-October). In the Bering and Chukchi Seas, distribution of survey effort and density of bowhead whales were examined during spring. Distribution of survey effort and density of gray whales in the Bering and Chukchi Seas were examined during summer (June-August).

METHODS

Map Preparation

Maps were prepared using the computer program AMP, A Mapping Package, consisting of FORTRAN subroutines which can be used for customized plotting applications. AMP was used to plot aerial survey data which resided on file as a series of geographic coordinates (latitude and longitude) associated with time and sightings of whales. Land masses are part of the AMP data base. Depth contours were plotted by reading a separate file of data points prepared for this analysis.

Depth contours were digitized using several reference maps. It was necessary to use more than one map because not all contours were available on any one map. The U.S. Geological Survey map Open - File 76 - 823, Sheet 1 or 2 was used to digitize the 50 m and greater depth contours, plus all contours shown in the Chukchi Sea except for the 30 m depth contour off the Soviet coastline. The 30 m depth contour off the Soviet coastline and in the Bering Sea was taken from U.S. Department of Commerce map 514, 4th Ed., Apr. 11/81. In the Beaufort Sea, the 10 m, 20 m, and 30 m depth contours were taken from two maps labeled Data from: Geophysical Corp. of Alaska, 1975, NOAA, Dept. of Commerce Charts, U.S.G.S. Dept. of Interior Charts which were additionally labeled as Eastern Beaufort Sea and Western Beaufort Sea.

When the depth contours were merged onto a single data file and plotted, some inconsistencies became apparent. For example, a 30 m depth contour from one map file crossed over the 50 m depth contour from another map file. When this situation occurred, a portion of one of the depth contours was clipped to resolve the inconsistency. Note that portions of the 20 m and 30 m depth contours were clipped near Pt. Barrow, Alaska, and that the 50 m depth contour was clipped near Saint Lawrence Island in the Bering Sea.

Data Processing and Quality Control

A computer program was written to screen for bad data values. The chronological order of time was checked. Aerial survey data files were screened for obvious errors in geographic position by plotting separately the course of each daily aerial survey. A computer program was used to calculate flight speeds and distances on a point to point basis, and listings of these values were scanned for suspiciously slow or fast speeds. The listings and maps were compared; errors were flagged and edited and the process was repeated until data files were error-free with respect to these conditions.

Definition of Areas and Methodological Limitations

The total Beaufort Sea study area was divided from east to west based on proximity to oil lease sites (Figure B-1). Region A is west and adjacent to the lease areas extending from 153° 30'W to 157° 00'W longitude. Region B extends from 150° 00'W to 153° 30'W longitude, representing the western lease area. Region C extends from 146° 00' to 150° 00'W longitude, representing the eastern lease area. And, Region D is east and adjacent to the lease area extending from 141° 00'W to 146° 00'W longitude.

Depth contours (Figure B-2) were used to stratify the Beaufort Sea from north to south corresponding to water depth. Preliminary analysis of survey data indicated that there was a relationship between water depth and distribution of bowhead whales. Depth contours of 10 m, 20 m, 50 m, 200 m, and 2000 m were selected (Figures B-3 and B-4).

The stratum from the coastline to 10 m corresponded closely to the area inside the barrier islands (A1, B1, C1, D1A, and D1B). Area D1 was divided into D1A and D1B at 143° 30'W, which marked the boundary between two areas previously defined for behavioral studies (Figure B-5).

The shelf area was stratified from 10 m to 20 m, 20 m to 50 m, and 50 m to 200 m. Areas A2, B2, C2, D2A, and D2B corresponded to the 10 m to 20 m strata. Area D2 was divided similarly to D1. Areas A3, B3, C3, and D3 corresponded to the 20 m and 50 m stratum. Areas A4, B4, C4, and D4 corresponded to the 50 m to 200 m stratum.

Offshelf strata were defined from 200 m to 2000 m and deeper than 2000 m. Areas A5, B5, C5, and D5 corresponded to the 200 m to 2000 m strata. Areas B6, C6, and D6 corresponded to the deeper than 2000 m strata.

The comparatively shallow Bering and Chukchi Seas were not subdivided on the basis of depth contours; rather, regions (Figures B-6 and B-7) were determined based on survey effort and animal distributions.

The digitizer was used to trace region boundaries, which led to a boundary problem termed "splinter error." The technique used to digitize each region was to circumscribe it by tracing the boundary of the region. Thus, when two regions were adjacent, the common boundary would be digitized twice. In fact, a boundary was often digitized more than twice. For example, the boundary between regions A1 and B1 was digitized four times because it served not only as a boundary between regions A1 and B1 but also between the larger regions A and B.

A splinter error occurred when one set of points defining a common boundary did not exactly match the second, third, or fourth set of points used to define the same boundary for other regions.

Because of this splinter error problem, a very small percentage of the total area may be shared by two regions or may be left out of a region. For example, because of overlap, a small portion of the Beaufort Sea may have been shared during the analysis of two adjacent regions. Conversely, if two sets of points defining a common boundary diverged slightly, a small protion of the Beaufort Sea could have been left out of the analysis.

The implications of the splinter error problem are small in relation to this study. Statistics reported for each subregion, region, and the total study area are valid, but there may be small discrepancies when the values of subregions are summed and compared to the values reported for larger regions, e.g., number of survey hours flown, listed in the tables as Survey Time.

Statistics Presented in Tables

Region Area nmi^2. Areas were approximated by straight line integration which contributed to discrepancies between the summation of subregion areas and areas calculated for larger regions. Area calculations are accurate to within about 1 percent of the true area.

Percent of Total Area. The percent of total area was calculated as the region area divided by the sum of all subregion areas; this quantity was then multiplied by 100.

Percent of Area Surveyed. The percent of area surveyed is a relative measure of survey effort expended per survey region. Strip width was defined as one nautical mile. Therefore, the total number of miles flown equalled the total number of square nautical miles surveyed. The percent of total area was calculated as the number of nautical miles surveyed divided by the region area; this quantity was then multiplied by 100.

This technique did not account for overlapping aerial survey strips which result in double counting the area surveyed. Therefore, some areas surveyed may show more than 100 percent coverage.

Survey Time HR:MIN. This is the time in hours and minutes spent surveying an area. Because of splinter errors and rounding errors, the values reported for time spent surveying subregions did not always equal those reported for larger regions.

Percent of Total Time. This is the time in hours and minutes spent surveying a region divided by the sum of survey times reported for each subregion.

Number of Transects Flown (=n). Transects or flight legs were defined as units of survey effort by the aerial survey team. The beginning and ending of transects were further defined by the survey region boundaries. A portion of an aerial survey leg passing over a region was treated as a transect relative to that region. Thus, one transect could be broken into several transects with respect to subregion analyses. For this reason, the sum of the transects based on subregions was greater than the total number of transects reported for the total region.

Number of Bowheads Observed. This indicates the number of bowhead whales observed within one-half nautical mile of either side of the aircraft. In contrast, whale sightings depicted on maps include all whales sighted, regardless of their distance from the aircraft. Because of splinter errors, small discrepancies may occur between the sum of the number of whales observed in each subregion, versus the number reported for larger regions.

Density as Number per nmi^2, Variance and Confidence Range. Calculation of density statistics for each stratum followed the method employed by Krogman et al (1979), which was based on the technique described in Estes and Gilbert (1978):

$$\hat{R} = \Sigma y_i / \Sigma x_i \qquad (1)$$

where $\hat{R}$ = observed density of whales per square nautical mile

y_i = number of whales observed in the ith strip transect

x_i = area of the ith strip transect

$$S^2_{\hat{R}} = [\Sigma(y_i^2/x_i) - \hat{R}\Sigma y_i] / (n-1)(\Sigma x_i) \qquad (2)$$

where $S^2_{\hat{R}}$ = variance of $\hat{R}$

n = number of strip transects

$$\text{C.I.} = \hat{R} \pm t_{.05(2)V} \sqrt{V(\hat{R})} \qquad (3)$$

The notation $t_{.05(2)V}$ refers to the critical value of t where alpha (α) = .05 ($1-\alpha = .95$) based on two tailed test with V degrees of freedom. Degrees of freedom were calculated as the total number of transects minus one.

Results and Discussion

Results are presented by area, season, and species. Each presentation consists of:

- Figure depicting aerial survey tracklines, sightings and region boundaries
- Figure depicting whale sightings, depth contours and/or region boundaries
- Table of statistics associated with each region presenting 1983 data summarized in subsequent figures
- Figure depicting percent aerial survey coverage for each region
- Figure depicting observed density of whales for each region
- Summary Table of statistics associated with each region, 1979-1982.

Please refer to the table of contents for order of presentation of aerial survey results. Figures and tables are intended to be self explanatory.

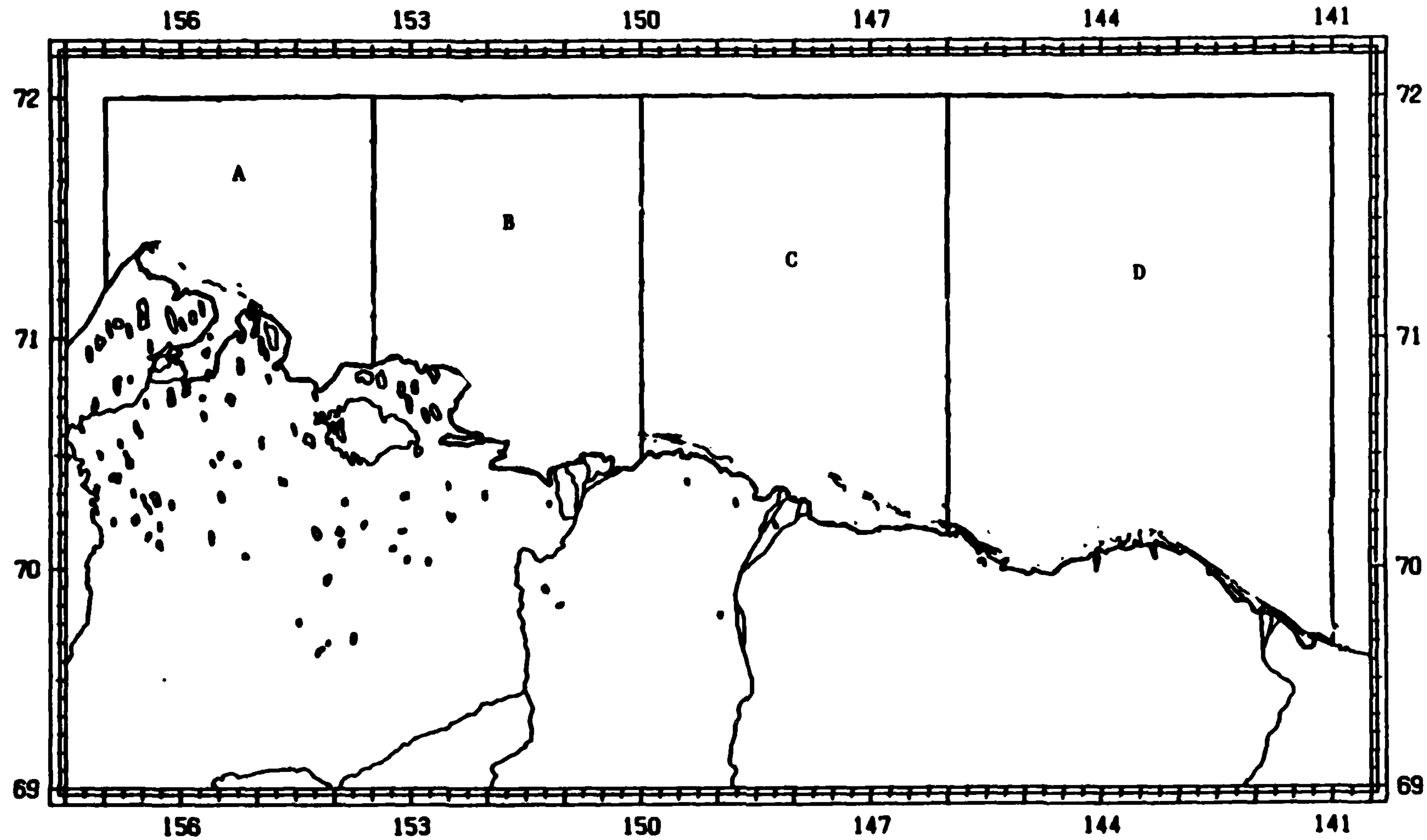

Figure B-1. The Beaufort Sea study area was divided into four regions: A, B, C, and D.

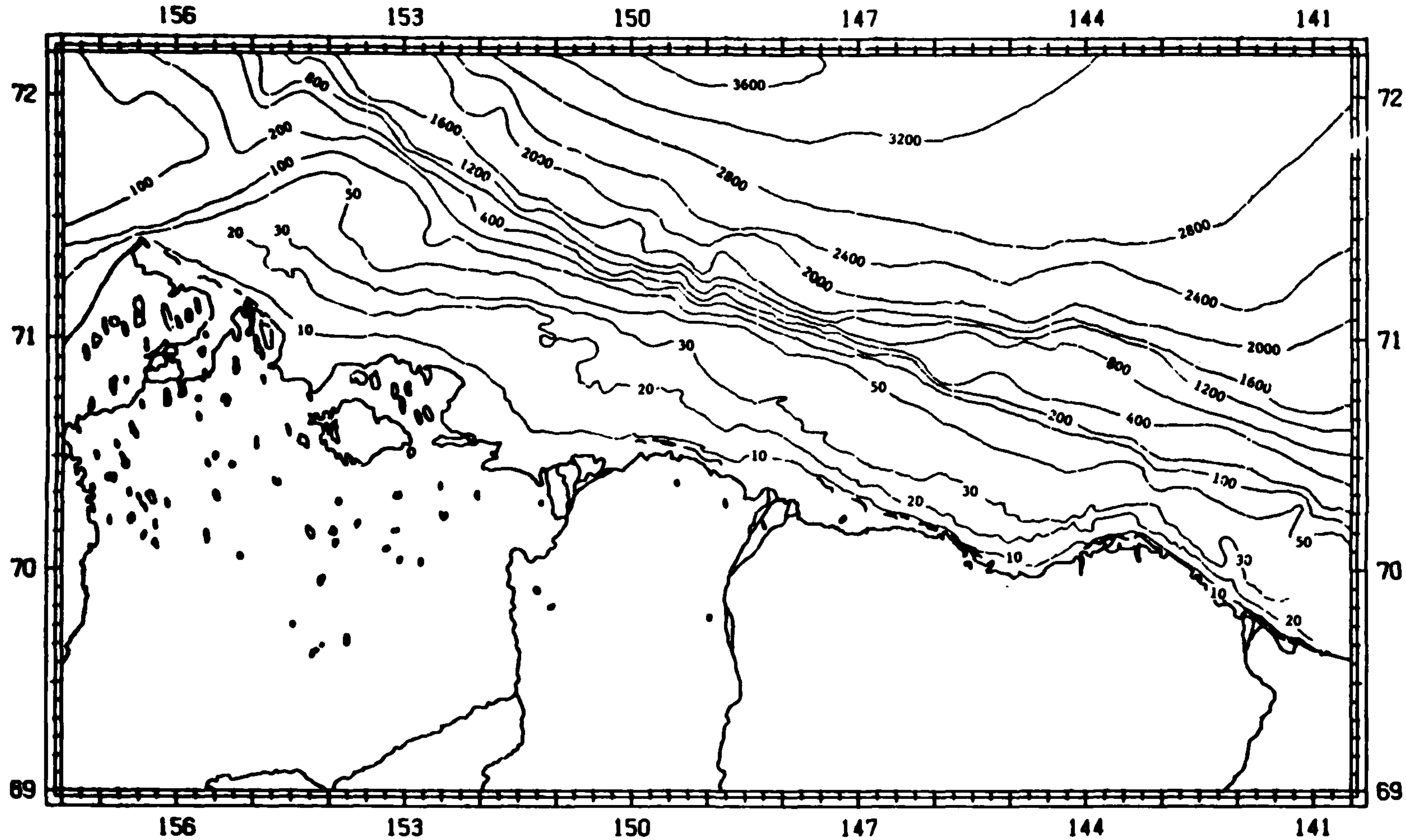

Figure B-2. Beaufort Sea depth contour lines, in meters.

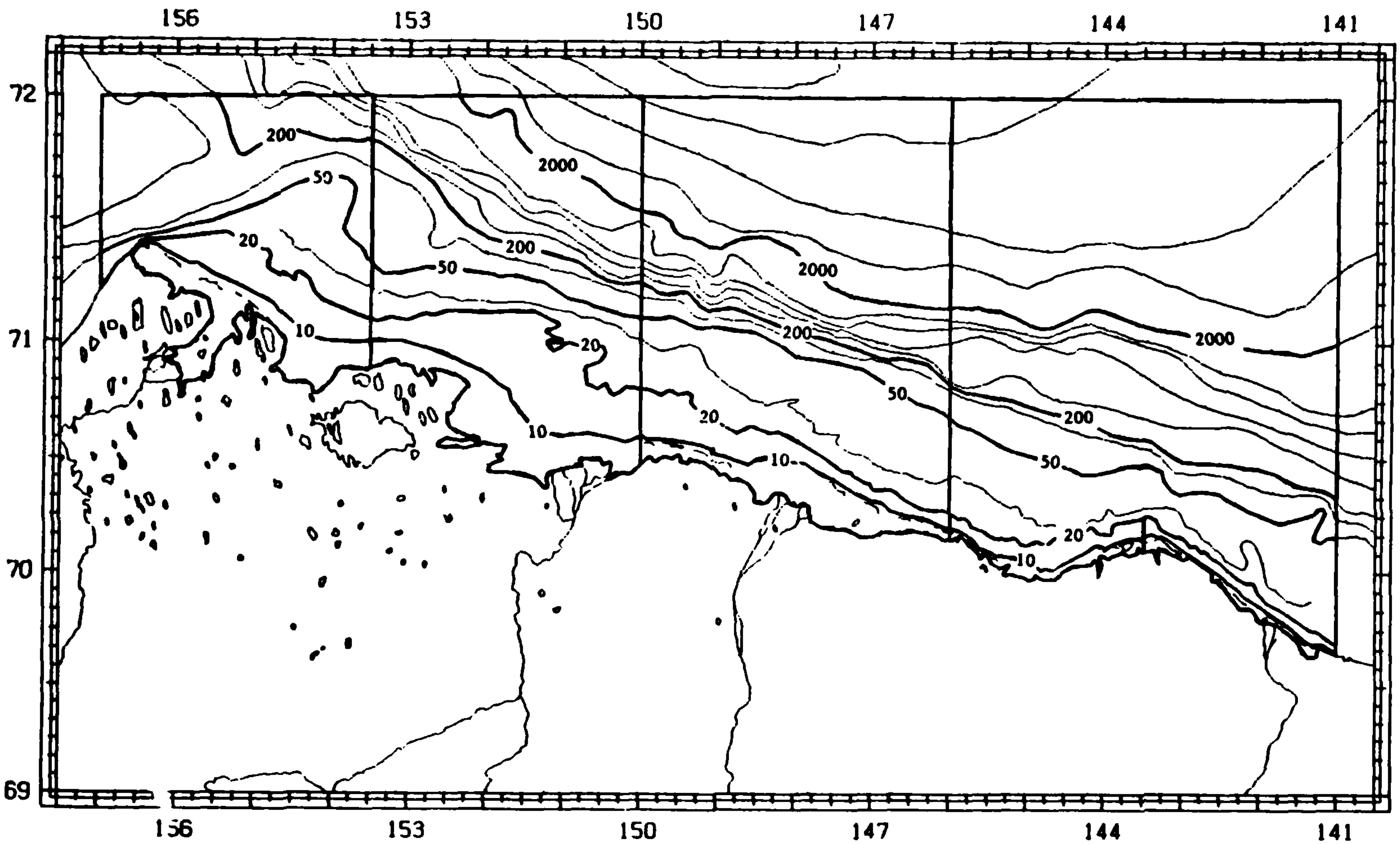

Figure B-3. Map depicting the survey regions in the Beaufort Sea after stratification by contour intervals of 10m, 20m, 50m, 200m, and 2000m.

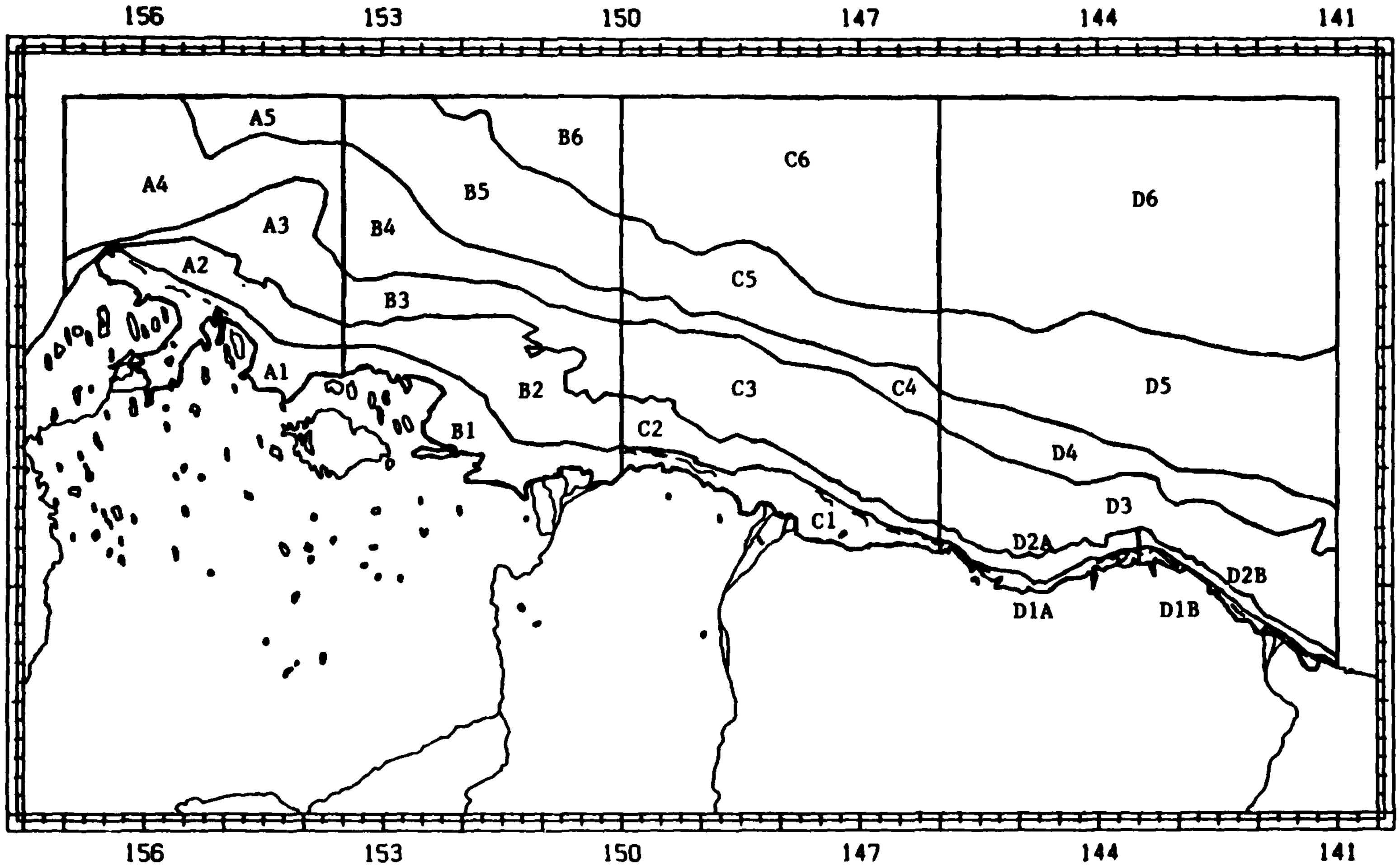

Figure B-4. Map depicting Beaufort Sea stratum names. Strata A1, B1, C1, D1A, and D1B extended from the coast out to the 10 meter depth contour. Strata A2, B2, C2, and D2A, and D2B fell between the 10 and 20 meter depth contours; A3, B3, C3, and D3 fell between the 20 and 50 meter depth contours; etc. Strata D1A, D1B, D2A, and D2B are enlarged in Figure B-5.

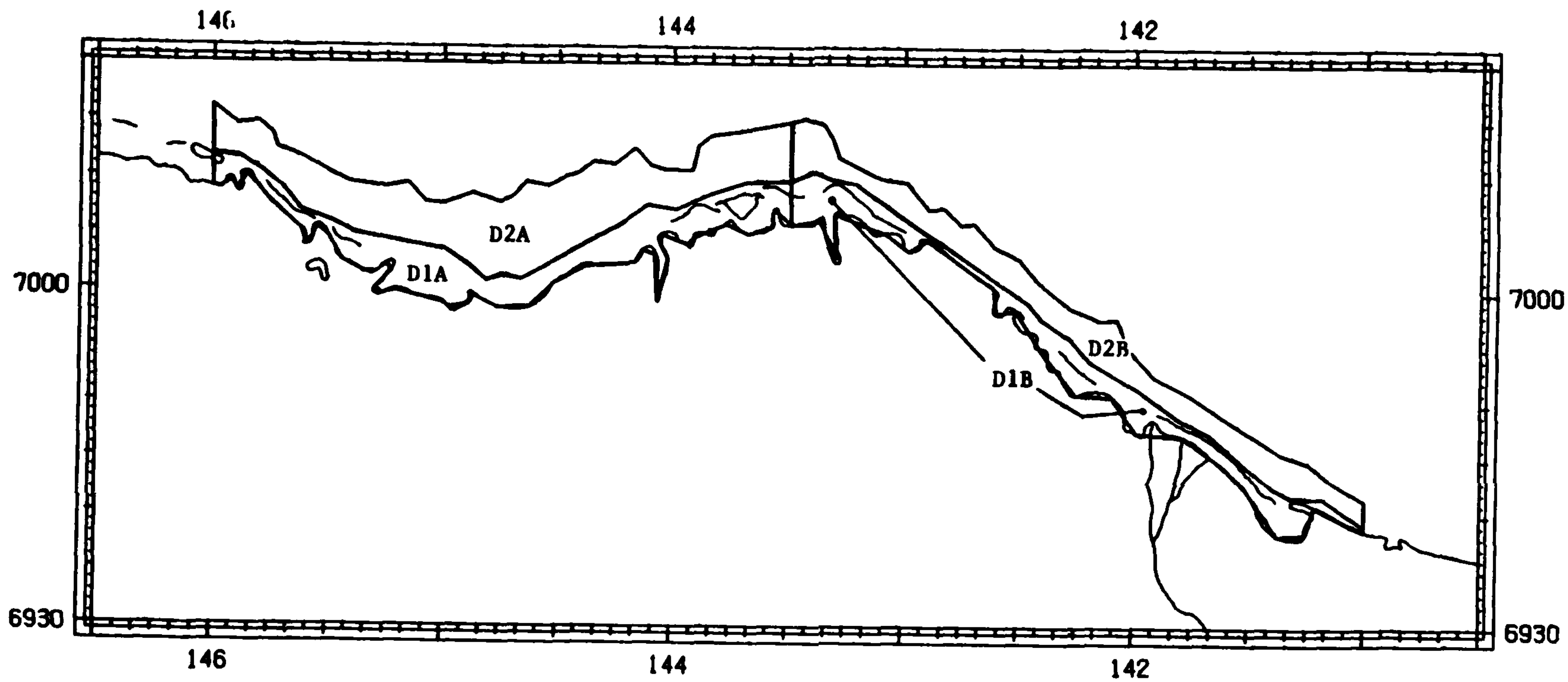

Figure B-5. Map depicting Beaufort Sea strata D1A, D1B, D2A, and D2B. Regions D1A and D1B extended from the coast out to the 10 meter depth contour. Regions D2A and D2B extended from the 10 meter to the 20 meter depth contour.

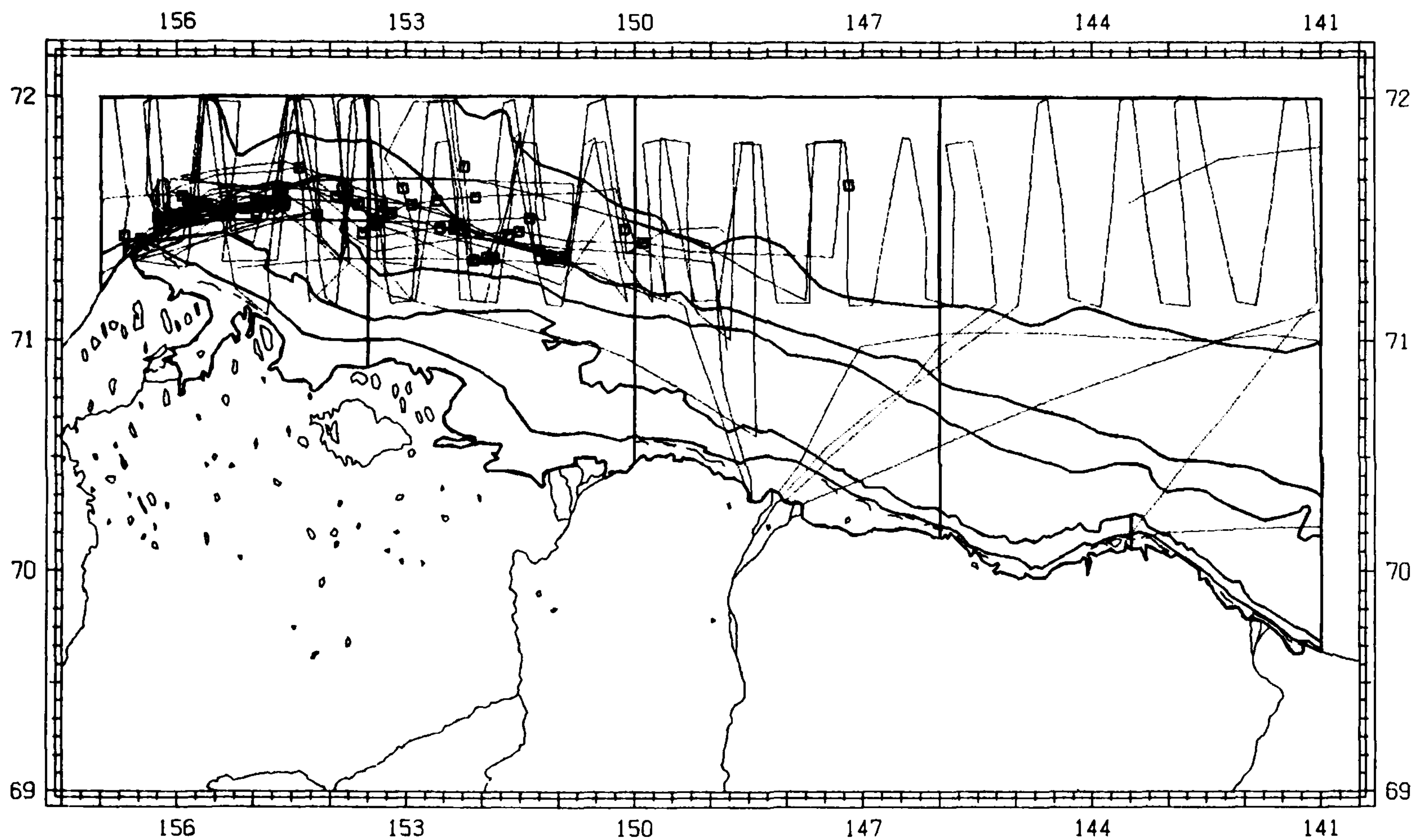

Figure B-6. Plot of aerial survey tracklines and bowhead whale sightings made during the April–May 1983 aerial survey of the Beaufort Sea.

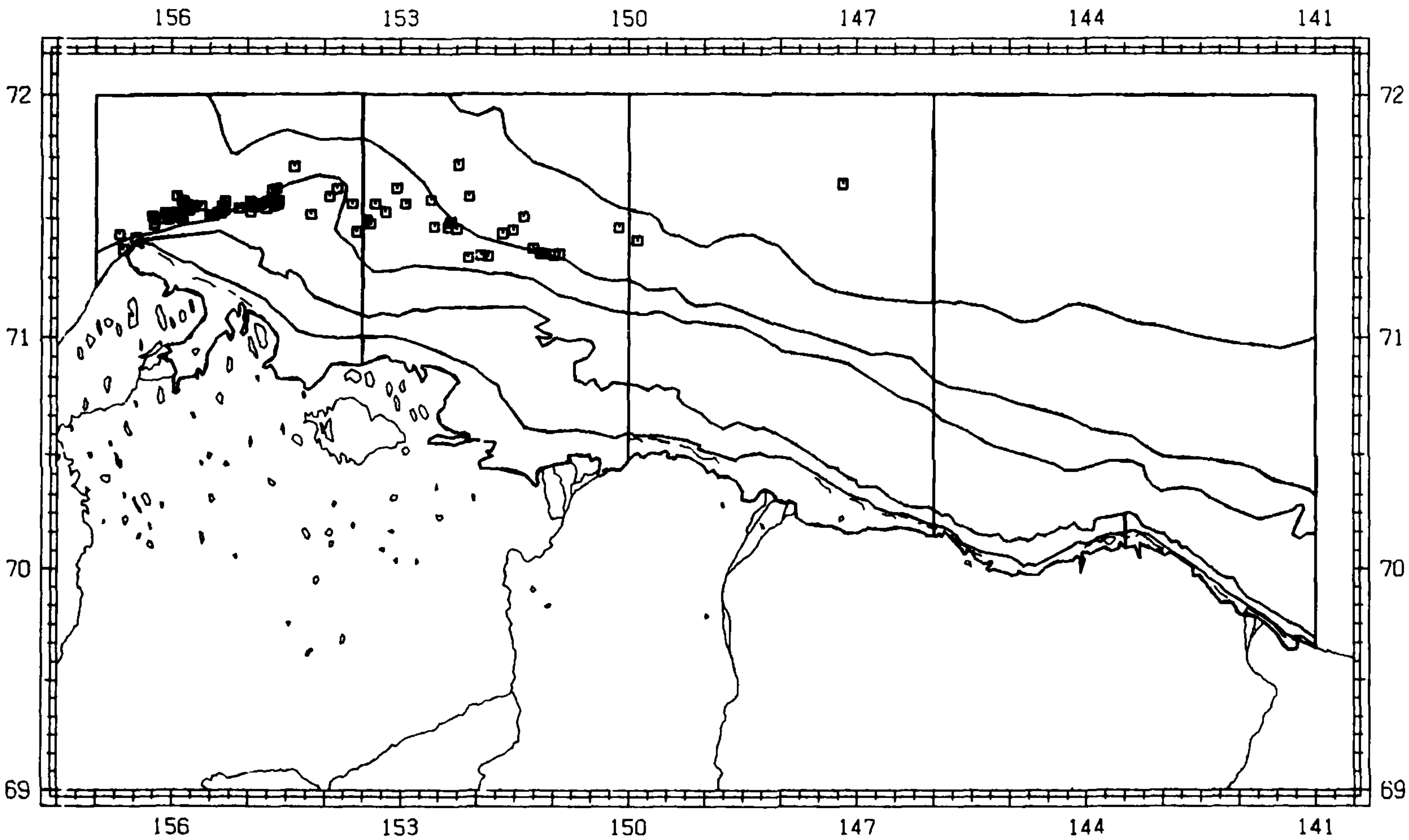

Figure B-7. Plot of bowhead whale sightings made during the April–May 1983 aerial survey of the Beaufort Sea.

Table B-1. Statistics from aerial surveys of bowhead whales conducted April-May 1983 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of sub-regions and the area calculated for the total region. Total time spent surveying was approximately 49 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
Total	28,609	100.	21.51	48:59	100.00	184	191	0.031	1.2	0.009 - 0.053
A	3,792	13.	56.22	18:26	37.63	89	122	0.057	7.4	0.003 - 0.111
A1	654	2.25	5.70	0:16	0.54	9	0	0.0	0.0	0.0 - 0.0
A2	479	1.65	18.24	0:39	1.33	13	0	0.0	0.0	0.0 - 0.0
A3	789	2.71	84.44	5:35	11.40	59	44	0.066	13.4	0.0 - 0.139
A4	1,518	5.22	77.69	10:42	21.84	81	78	0.066	10.7	0.001 - 0.131
A5	384	1.32	42.98	1:16	2.59	27	0	0.0	0.0	0.0 - 0.0
B	5,569	19.	33.60	15:20	31.30	62	69	0.037	1.2	0.015 - 0.059
B1	739	2.54	0.0							
B2	1,079	3.71	2.93	0:09	0.31	2	0	0.0	0.0	0.0 - 0.0
B3	793	2.73	16.30	0:52	1.77	17	0	0.0	0.0	0.0 - 0.0
B4	893	3.07	76.31	6:10	12.59	48	53	0.078	8.5	0.019 - 0.136
B5	1,463	5.03	58.45	6:46	13.81	46	17	0.020	8.7	0.0 - 0.079
B6	659	2.27	26.29	1:23	2.82	19	0	0.0	0.0	0.0 - 0.0
C	7,701	27.	15.18	8:18	16.94	39	0	0.0	0.0	0.0 - 0.0
C1	584	2.02	4.82	0:08	0.27	6	0	0.0	0.0	0.0 - 0.0
C2	528	1.82	7.59	0:14	0.48	8	0	0.0	0.0	0.0 - 0.0
C3	1,910	6.57	11.87	1:23	2.82	12	0	0.0	0.0	0.0 - 0.0
C4	486	1.67	16.40	0:41	1.40	13	0	0.0	0.0	0.0 - 0.0
C5	1,224	4.21	30.16	2:44	5.58	29	0	0.0	0.0	0.0 - 0.0
C6	3,070	10.56	15.56	3:32	7.21	27	0	0.0	0.0	0.0 - 0.0
D	11,625	41.	7.98	6:29	13.24	26	0	0.0	0.0	0.0 - 0.0
D1A	156	0.55	1.78	0:04	0.14	1	0	0.0	0.0	0.0 - 0.0
D1B	123	0.42	1.59	0:01	0.03	1	0	0.0	0.0	0.0 - 0.0
D2A	257	0.88	.16	0:01	0.03	1	0	0.0	0.0	0.0 - 0.0
D2B	155	0.53	4.82	0:06	0.20	2	0	0.0	0.0	0.0 - 0.0
D3	1,997	6.87	2.81	0:21	0.71	3	0	0.0	0.0	0.0 - 0.0
D4	1,018	3.50	3.17	0:13	0.44	3	0	0.0	0.0	0.0 - 0.0
D5	2,809	9.66	6.98	1:22	2.79	6	0	0.0	0.0	0.0 - 0.0
D6	5,303	18.24	11.37	4:13	8.61	24	0	0.0	0.0	0.0 - 0.0

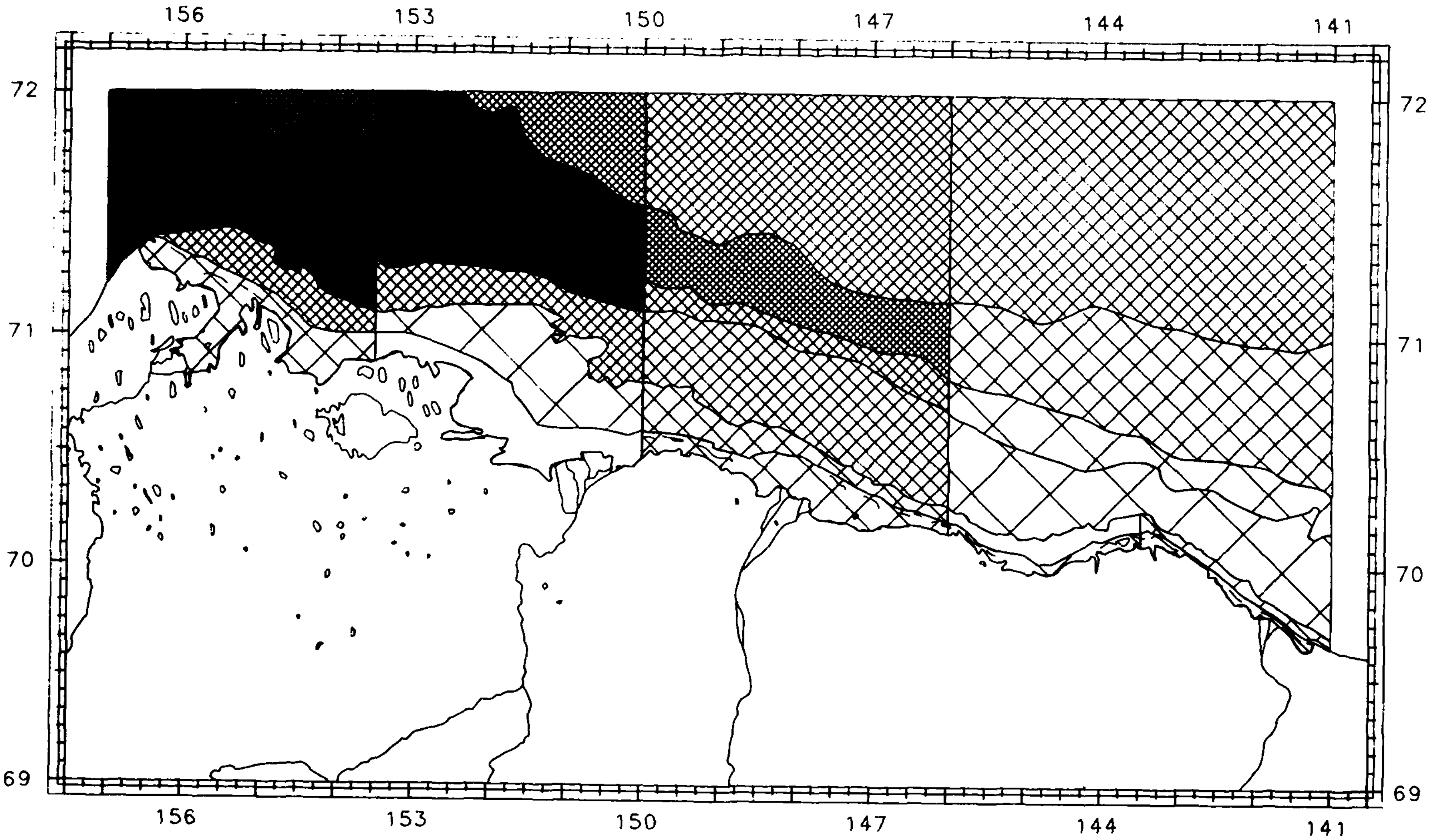

Figure B-8. Shaded regions represent percentages expressed as total number of survey track miles flown divided by the area of each region. Shading varies from all white (representing 0 percent) to all black (representing 150 percent). Data are based on the April–May 1983 Beaufort Sea aerial survey.

Table B-2. Statistics from aerial survey of bowhead whales conducted April-May 1979-1983 in the Beaufort Sea.

		1979				1980				1981				1982				1983			
Region Name	Region Area nmi^2	Percent of Area Surveyed	Number of Transects Flown (±n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number of Transects Flown (±n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number of Transects Flown (±n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number of Transects Flown (±n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number of Transects Flown (±n)	Number of Bowheads Observed	Density as Number per nmi^2
Total	28,609	8.45	55	14	0.006	11.18	28	268	0.084	19.27	22	271	0.049	17.13	29	134	0.027	21.51	184	191	0.031
A	3,792	10.79	15	14	0.034	36.05	26	175	0.128	33.51	15	100	0.079	31.15	31	75	0.063	56.22	89	122	0.057
A1	654	9.49	5	0	0.0	12.68	15	0	0.0	0.74	2	0	0.0	4.62	10	0	0.0	5.70	9	0	0.0
A2	479	13.05	4	0	0.0	7.13	9	0	0.0	1.39	2	0	0.0	7.05	9	0	0.0	18.24	13	0	0.0
A3	789	13.58	8	0	0.0	47.12	35	58	0.156	83.77	25	42	0.064	61.67	33	15	0.031	84.44	59	44	0.066
A4	1,518	9.88	8	13	0.087	54.49	36	117	0.141	38.24	35	53	0.091	38.81	39	60	0.102	77.69	81	78	0.066
A5	384	3.58	1	0	0.0	12.81	6	0	0.0	5.07	2	5	0.256	10.78	2	0	0.0	42.98	27	0	0.0
B	5,569	8.41	7	0	0.0	14.40	11	58	0.072	38.25	26	150	0.070	25.24	19	52	0.037	33.60	62	69	0.037
B1	739	4.37	3	0	0.0	6.12	2	0	0.0	7.57	2	0	0.0	0.0				0.0			
B2	1,079	19.05	9	0	0.0	2.35	2	0	0.0	15.60	9	0	0.0	9.38	3	0	0.0	2.93	2	0	0.0
B3	793	20.46	9	0	0.0	3.06	3	0	0.0	16.74	14	0	0.0	17.44	8	0	0.0	16.30	17	0	0.0
B4	893	7.58	3	0	0.0	42.80	15	25	0.065	87.22	34	56	0.072	65.66	23	29	0.049	76.31	48	53	0.078
B5	1,463	0.0				22.15	11	33	0.102	68.10	23	93	0.093	31.99	16	22	0.047	58.45	46	17	0.020
B6	659	0.0				0.00				5.33	4	1	0.028	16.93	5	1	0.009	26.29	19	0	0.0
C	7,701	19.55	45	0	0.0	7.28	11	24	0.043	19.38	26	13	0.009	21.68	19	7	0.004	15.18	39	0	0.0
C1	584	80.45	35	0	0.0	14.90	6	0	0.0	2.64	3	0	0.0	11.15	7	0	0.0	4.82	6	0	0.0
C2	528	88.28	44	0	0.0	10.64	7	0	0.0	15.41	9	0	0.0	20.23	13	0	0.0	7.59	8	0	0.0
C3	1,910	27.51	44	0	0.0	5.76	7	0	0.0	12.67	15	0	0.0	26.36	15	0	0.0	11.87	12	0	0.0
C4	486	.89	1	0	0.0	10.77	5	0	0.0	26.95	16	0	0.0	19.48	13	0	0.0	16.40	13	0	0.0
C5	1,224	1.57	1	0	0.0	9.13	6	1	0.009	50.94	27	6	0.010	22.31	19	3	0.011	30.16	29	0	0.0
C6	3,070	1.25	1	0	0.0	4.66	4	23	0.161	12.90	13	7	0.018	20.33	15	4	0.006	15.56	27	0	0.0
D	11,625	0.26	3	0	0.0	4.07	4	11	0.023	5.37	11	8	0.013	5.58	6	0	0.0	7.98	26	0	0.0
D1A	156	0.0				2.31	1	0	0.0	2.96	1	0	0.0	0.0				1.78	1	0	0.0
D1B	123	0.0				0.00				12.26	4	0	0.0	0.0				1.59	1	0	0.0
D2A	257	1.26	2	0	0.0	8.50	4	0	0.0	2.11	1	0	0.0	0.0				.16	1	0	0.0
D2B	155	0.0				2.33	2	0	0.0	24.88	3	0	0.0	1.26	1	0	0.0	4.82	2	0	0.0
D3	1,997	0.69	2	0	0.0	7.30	4	0	0.0	4.79	6	0	0.0	5.99	3	0	0.0	2.81	3	0	0.0
D4	1,018	0.0				1.64	2	0	0.0	5.26	4	0	0.0	6.48	3	0	0.0	3.17	3	0	0.0
D5	2,809	0.0				3.16	2	1	0.011	8.32	7	7	0.030	4.00	6	0	0.0	6.98	6	0	0.0
D6	5,303	0.0				3.65	4	10	0.052	3.34	5	1	0.006	6.57	5	0	0.0	11.37	24	0	0.0

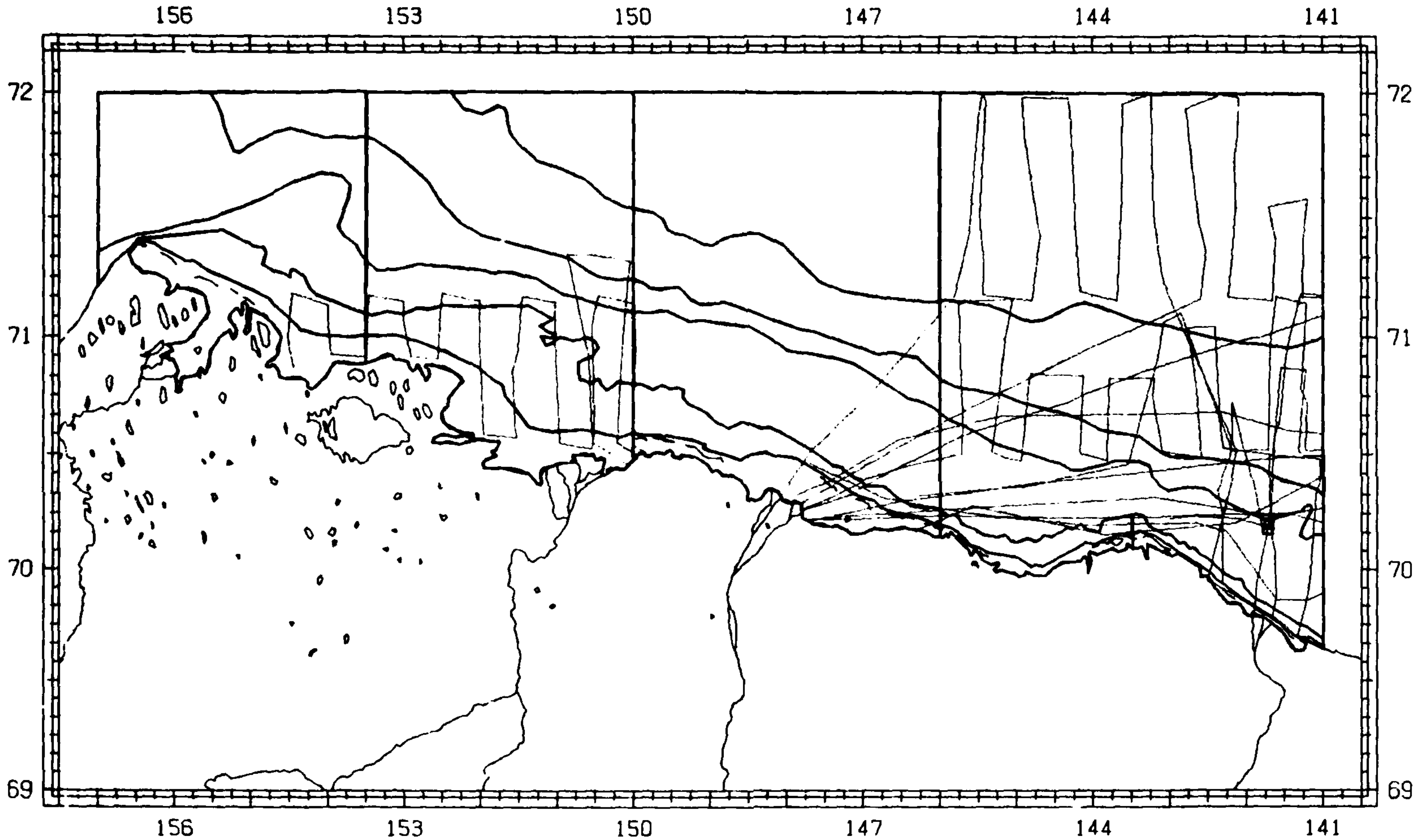

Figure B-10. Plot of aerial survey tracklines and bowhead whale sightings made during the August 1-15, 1983 aerial survey of the Beaufort Sea.

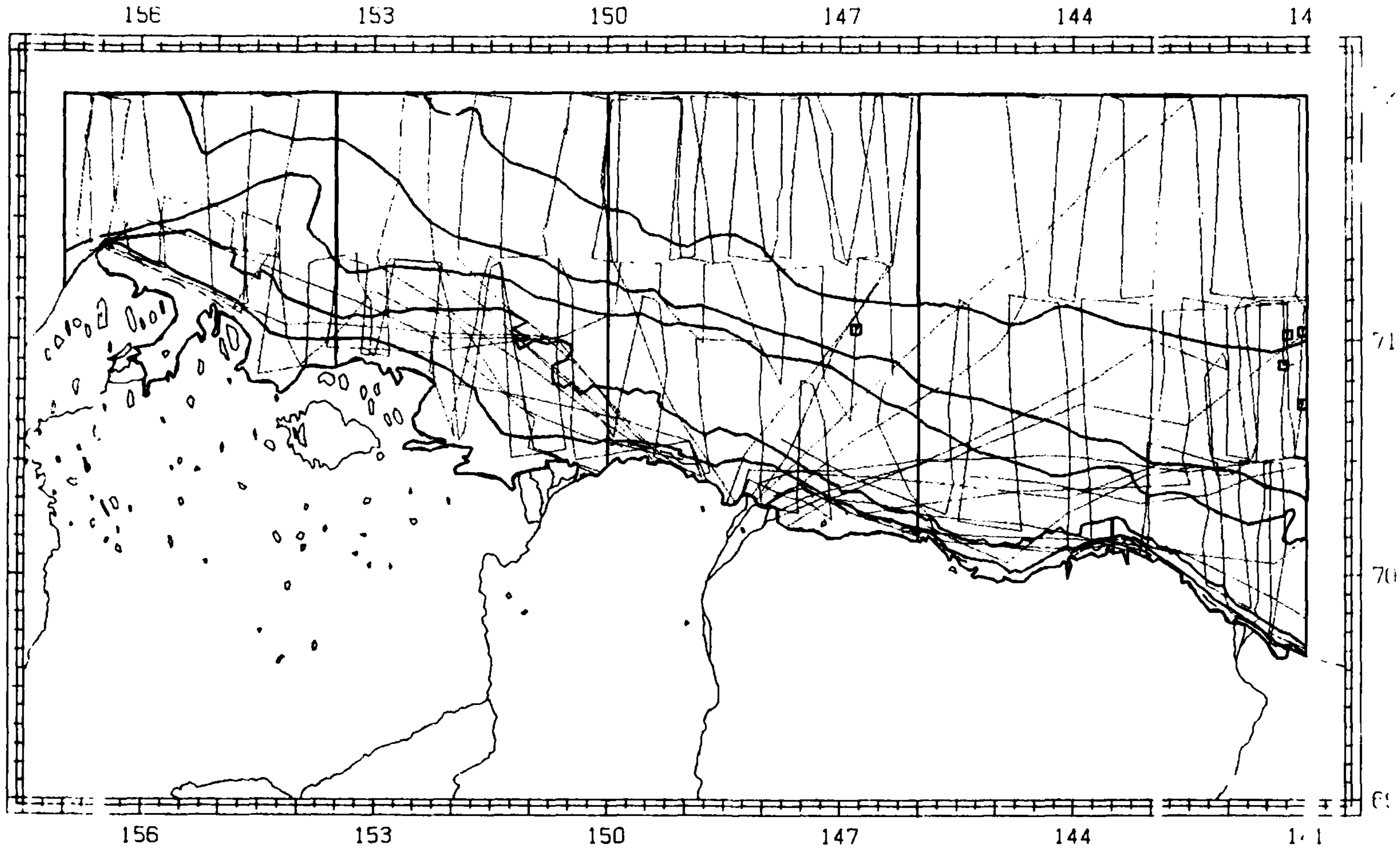

Figure B-11. Plot of aerial survey tracklines and bowhead whale sightings made during the August 16-30, 1983 aerial survey of the Beaufort Sea.

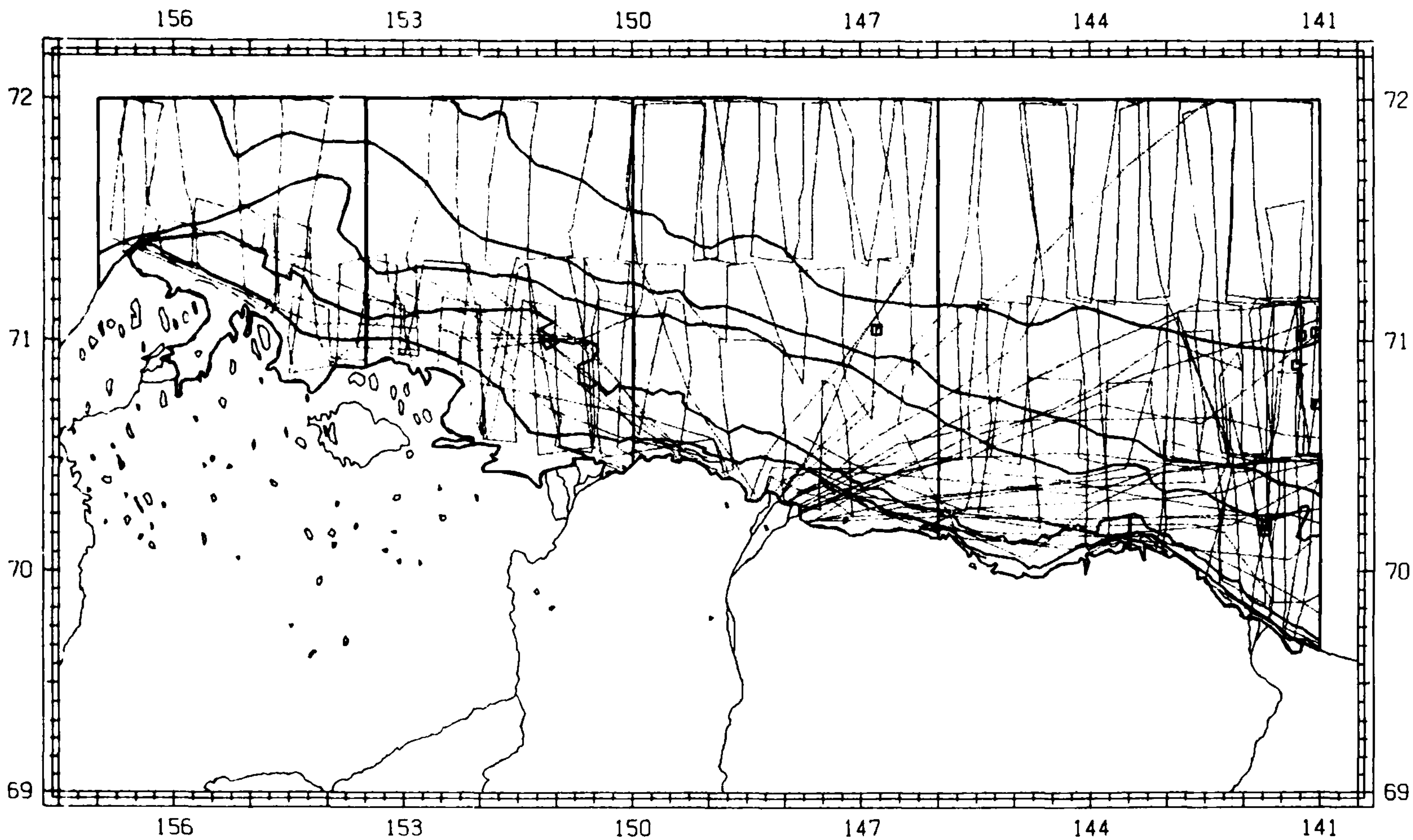

Figure B-12. Plot of aerial survey tracklines and bowhead whale sightings made during the August 1983 aerial survey of the Beaufort Sea.

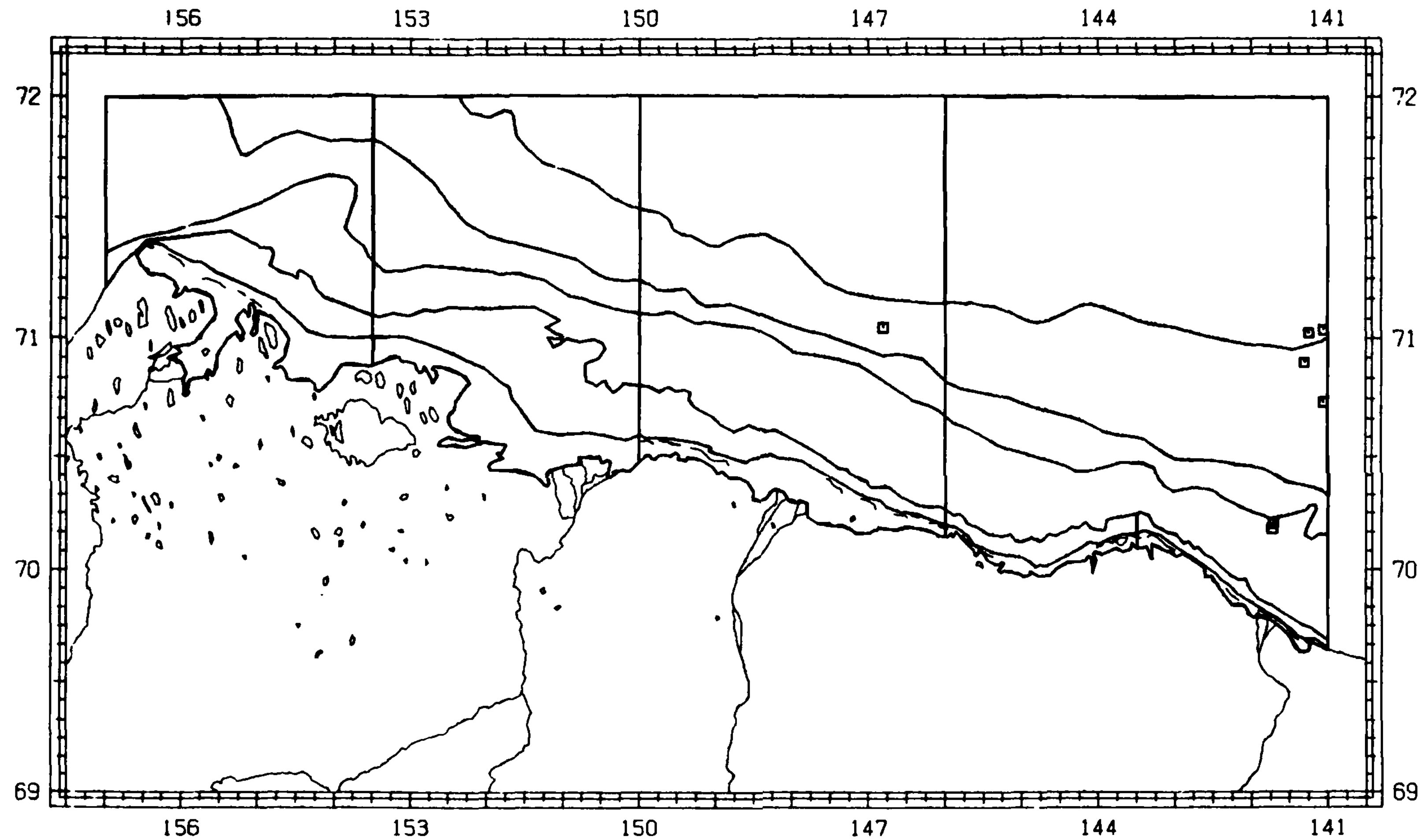

Figure B-13. Plot of bowhead whale sightings made during the August 1983 aerial survey of the Beaufort Sea.

Table B-3. Statistics from aerial surveys of bowhead whales conducted August 1983 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of sub-regions and the area calculated for the total region. Total time spent surveying was approximately 75 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Variance	Confidence Range of Density
Total	28,609	100.	36.18	74:44	100.00	330	10	0.001	>0.0	>0.0 - 0.002
A	3,792	13.	21.67	6:24	8.56	38	0	0.0	0.0	0.0 - 0.0
A1	654	2.25	24.31	1:20	1.78	24	0	0.0	0.0	0.0 - 0.0
A2	479	1.65	33.17	1:11	1.58	22	0	0.0	0.0	0.0 - 0.0
A3	789	2.71	26.67	1:37	2.16	23	0	0.0	0.0	0.0 - 0.0
A4	1,518	5.22	16.45	1:58	2.63	15	0	0.0	0.0	0.0 - 0.0
A5	384	1.32	11.23	0:19	0.42	4	0	0.0	0.0	0.0 - 0.0
B	5,569	19.	33.21	13:43	18.35	77	0	0.0	0.0	0.0 - 0.0
B1	739	2.54	38.64	2:10	2.90	41	0	0.0	0.0	0.0 - 0.0
B2	1,079	3.71	65.24	4:59	6.67	47	0	0.0	0.0	0.0 - 0.0
B3	793	2.73	50.90	2:55	3.90	42	0	0.0	0.0	0.0 - 0.0
B4	893	3.07	19.12	1:23	1.85	32	0	0.0	0.0	0.0 - 0.0
B5	1,463	5.03	12.40	1:21	1.81	15	0	0.0	0.0	0.0 - 0.0
B6	659	2.27	15.55	0:54	1.20	11	0	0.0	0.0	0.0 - 0.0
C	7,701	27.	31.52	17:25	23.31	102	1	>0.0	>0.0	>0.0 - 0.001
C1	584	2.02	65.32	2:47	3.72	41	0	0.0	0.0	0.0 - 0.0
C2	528	1.82	53.72	2:02	2.72	37	0	0.0	0.0	0.0 - 0.0
C3	1,910	6.57	35.07	4:38	6.20	41	0	0.0	0.0	0.0 - 0.0
C4	486	1.67	24.39	0:50	1.12	24	0	0.0	0.0	0.0 - 0.0
C5	1,224	4.21	20.34	1:50	2.45	30	1	0.004	>0.0	>0.0 - 0.01
C6	3,070	10.56	23.48	5:18	7.09	36	0	0.0	0.0	0.0 - 0.0
D	11,625	41.	45.28	37:17	49.89	163	9	0.002	>0.0	>0.0 - 0.004
D1A	156	0.55	36.62	0:23	0.51	11	0	0.0	0.0	0.0 - 0.0
D1B	123	0.42	66.13	0:35	0.78	21	0	0.0	0.0	0.0 - 0.0
D2A	257	0.88	68.66	1:09	1.54	20	0	0.0	0.0	0.0 - 0.0
D2B	155	0.53	57.30	0:39	0.87	24	0	0.0	0.0	0.0 - 0.0
D3	1,997	6.87	65.32	9:12	12.31	64	2	0.002	>0.0	>0.0 - 0.008
D4	1,018	3.50	55.45	3:55	5.24	52	0	0.0	0.0	0.0 - 0.0
D5	2,809	9.66	53.55	10:41	14.30	81	3	0.002	>0.0	>0.0 - 0.006
D6	5,303	18.24	28.08	10:42	14.32	82	4	0.003	>0.0	>0.0 - 0.008

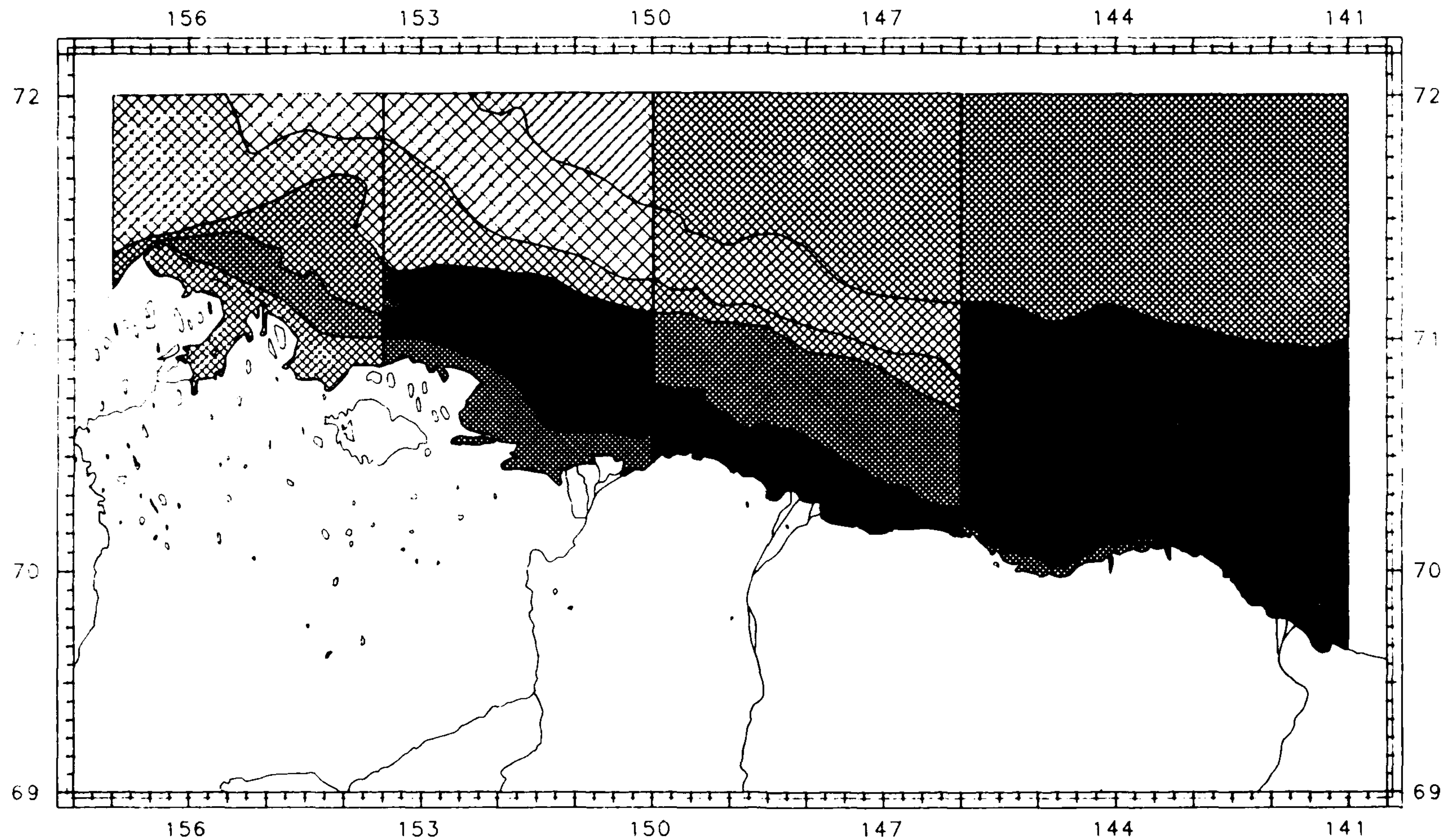

Figure B-14. Shaded regions represent percentages expressed as total number of survey track miles flown divided by the area of each region. Shading varies from all white (representing 0 percent) to all black (representing 150 percent). Data are based on the August 1983 Beaufort Sea aerial survey.

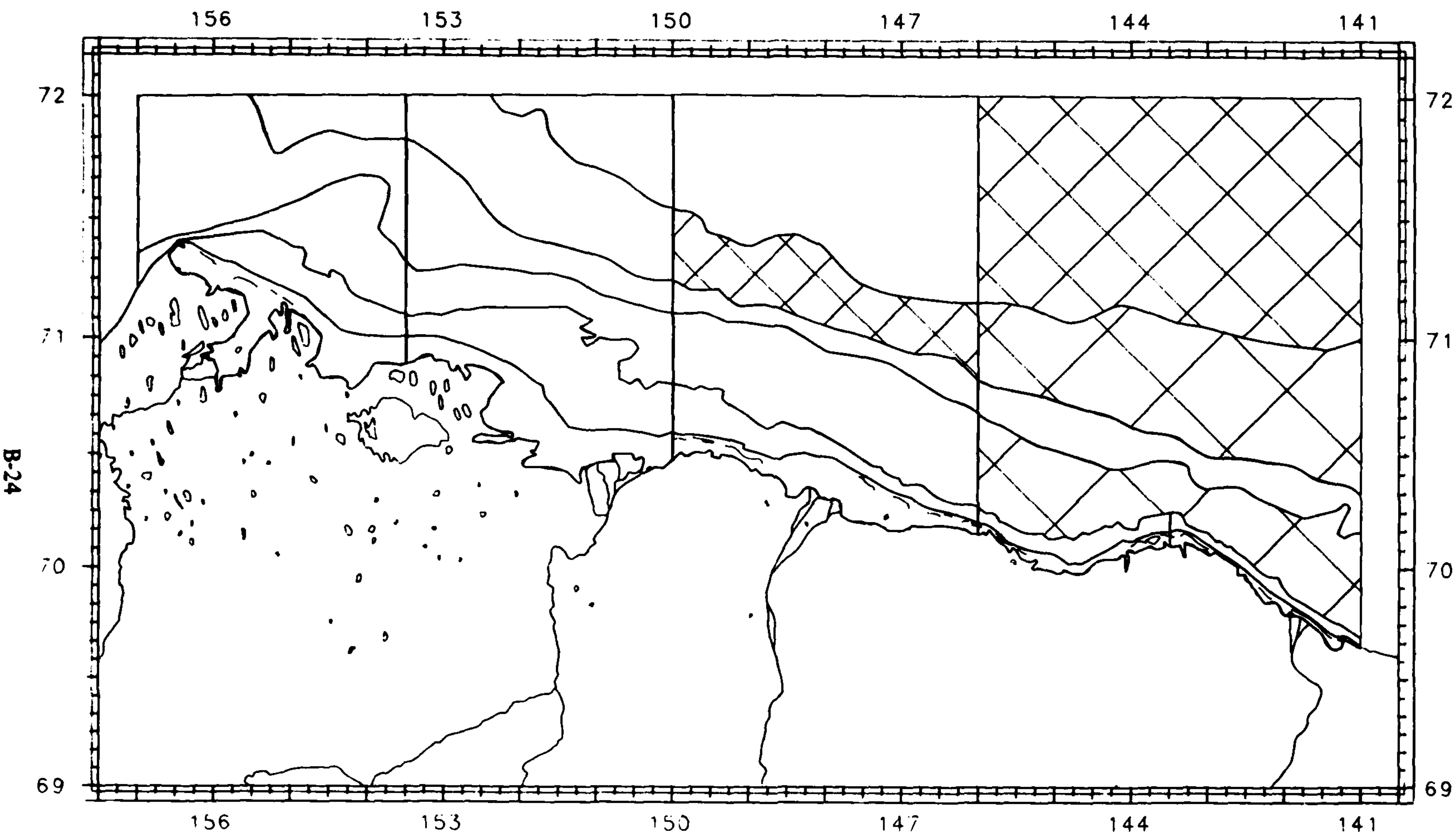

Figure B-15. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Beaufort Sea during August 1983. Shading varies from all white (representing 0 density) to all black (representing 0.110 density).

Table B-4. Statistics from aerial surveys of bowhead whales conducted August 1979-1982.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2
		1979							1980					
Total	28,609	100.	14.43	44:29	100.00	25	7	0.002	8.29	24:41	100.00	17	0	0.0
A	3,792	13.	0.0						1.94	0:31	2.09	2	0	0.0
A1	654	2.25	0.0						3.38	0:11	0.74	2	0	0.0
A2	479	1.65	0.0						3.37	0:07	0.47	2	0	0.0
A3	789	2.71	0.0						4.25	0:12	0.81	2	0	0.0
A4	1,518	5.22	0.0						0.15	0:01	0.07	2	0	0.0
A5	384	1.32	0.0						0.0					
B	5,569	19.	0.0						16.36	7:43	31.26	10	0	0.0
B1	739	2.54	0.0						36.89	2:10	8.78	19	0	0.0
B2	1,079	3.71	0.0						31.23	3:00	12.15	17	0	0.0
B3	793	2.73	0.0						20.23	1:07	4.52	14	0	0.0
B4	893	3.07	0.0						12.59	1:16	5.13	10	0	0.0
B5	1,463	5.03	0.0						1.90	0:10	0.68	2	0	0.0
B6	659	2.27	0.0						0.0					
C	7,701	27.	30.37	27:12	61.15	23	0	0.0	12.53	13:16	53.75	9	0	0.0
C1	584	2.02	134.66	9:53	22.22	49	0	0.0	32.67	7:23	29.91	17	0	0.0
C2	528	1.82	68.95	3:15	7.31	68	0	0.0	31.04	1:38	6.62	20	0	0.0
C3	1,910	6.57	54.34	9:04	20.38	42	0	0.0	29.67	3:57	16.00	15	0	0.0
C4	486	1.67	8.69	0:32	1.20	7	0	0.0	8.49	0:17	1.15	4	0	0.0
C5	1,224	4.21	7.83	3:44	8.39	8	0	0.0	0.24	0:01	0.07	1	0	0.0
C6	3,070	10.56	2.58	1:09	2.59	5	0	0.0	0.0					
D	11,625	41.	15.40	17:20	38.97	19	7	0.004	3.45	3:09	12.76	5	0	0.0
D1A	156	0.55	15.04	0:14	0.52	11	0	0.0	11.44	0:09	0.61	2	0	0.0
D1B	123	0.42	0.0						4.93	0:03	0.20	1	0	0.0
D2A	257	0.88	111.90	3:30	7.87	34	0	0.0	2.85	0:04	0.27	2	0	0.0
D2B	155	0.53	9.68	0:08	0.30	3	0	0.0	8.11	0:06	0.41	3	0	0.0
D3	1,997	6.87	44.65	7:24	16.64	46	0	0.0	17.48	2:44	11.07	6	0	0.0
D4	1,018	3.50	31.73	3:52	8.69	24	4	0.012	0.74	0:03	0.20	1	0	0.0
D5	2,809	9.66	7.05	1:53	4.23	8	3	0.015	0.0					
D6	5,303	18.24	0.0						0.0					
		1981							1982					
Total	28,609	100.	6.66	14:03	100.00	22	0	0.0	26.94	67:22	100.00	312	79	0.01
A	3,792	13.	5.72	1:38	11.63	7	0	0.0	0.0					
A1	654	2.25	8.20	0:30	3.56	5	0	0.0	0.0					
A2	479	1.65	5.56	0:05	0.59	3	0	0.0	0.0					
A3	789	2.71	9.76	0:40	4.74	6	0	0.0	0.0					
A4	1,518	5.22	4.00	0:25	2.97	2	0	0.0	0.0					
A5	384	1.32	0.0						0.0					
B	5,569	19.	7.87	2:44	19.45	5	0	0.0	0.0					
B1	739	2.54	10.96	0:41	4.86	4	0	0.0	0.0					
B2	1,079	3.71	10.22	0:45	5.34	9	0	0.0	0.0					
B3	793	2.73	19.62	0:54	6.41	8	0	0.0	0.0					
B4	893	3.07	6.71	0:18	2.14	3	0	0.0	0.0					
B5	1,463	5.03	2.12	0:06	0.71	1	0	0.0	0.0					
B6	659	2.27	0.0						0.0					
C	7,701	27.	9.09	6:15	44.48	16	0	0.0	17.77	13:17	19.72	54	0	0.0
C1	584	2.02	28.30	1:41	11.98	14	0	0.0	45.68	5:26	8.07	31	0	0.0
C2	528	1.82	41.87	2:24	17.08	17	0	0.0	22.62	0:53	1.31	23	0	0.0
C3	1,910	6.57	10.12	1:25	10.08	12	0	0.0	24.20	3:20	4.95	30	0	0.0
C4	486	1.67	2.06	0:04	0.47	2	0	0.0	23.77	0:49	1.21	18	0	0.0
C5	1,224	4.21	2.90	0:13	1.54	2	0	0.0	21.41	1:52	2.77	22	0	0.0
C6	3,070	10.56	2.44	0:29	3.44	2	0	0.0	4.68	0:58	1.43	12	0	0.0
D	11,625	41.	4.71	3:23	24.08	9	0	0.0	54.57	54:08	80.36	280	79	0.012
D1A	156	0.55	0.0						140.15	3:05	4.58	63	0	0.0
D1B	123	0.42	3.93	0:01	0.12	1	0	0.0	57.24	0:39	0.96	22	0	0.0
D2A	257	0.88	17.43	0:14	1.66	8	0	0.0	109.20	3:11	4.73	47	0	0.0
D2B	155	0.53	7.22	0:03	0.36	4	0	0.0	123.46	1:29	2.20	40	0	0.0
D3	1,997	6.87	21.82	2:42	19.22	12	0	0.0	80.48	12:25	18.43	119	0	0.0
D4	1,018	3.50	0.0						84.05	6:32	9.70	115	3	0.004
D5	2,809	9.66	1.83	0:24	2.85	1	0	0.0	67.16	17:05	25.36	114	72	0.038
D6	5,303	18.24	0.0						23.14	9:41	14.37	94	4	0.003

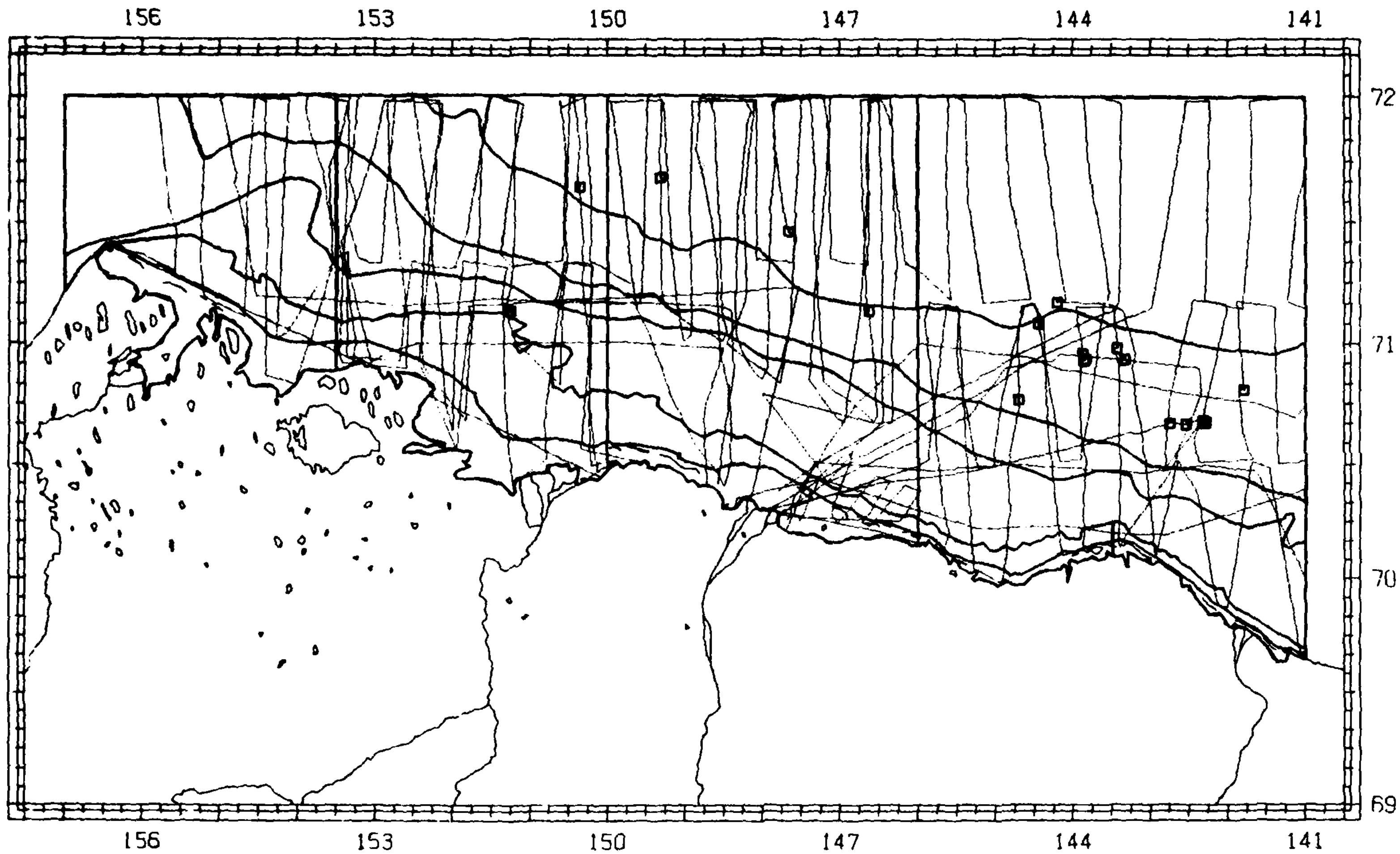

Figure B-16. Plot of aerial survey tracklines and bowhead whale sightings made during the September 1-15, 1983 aerial survey of the Beaufort Sea.

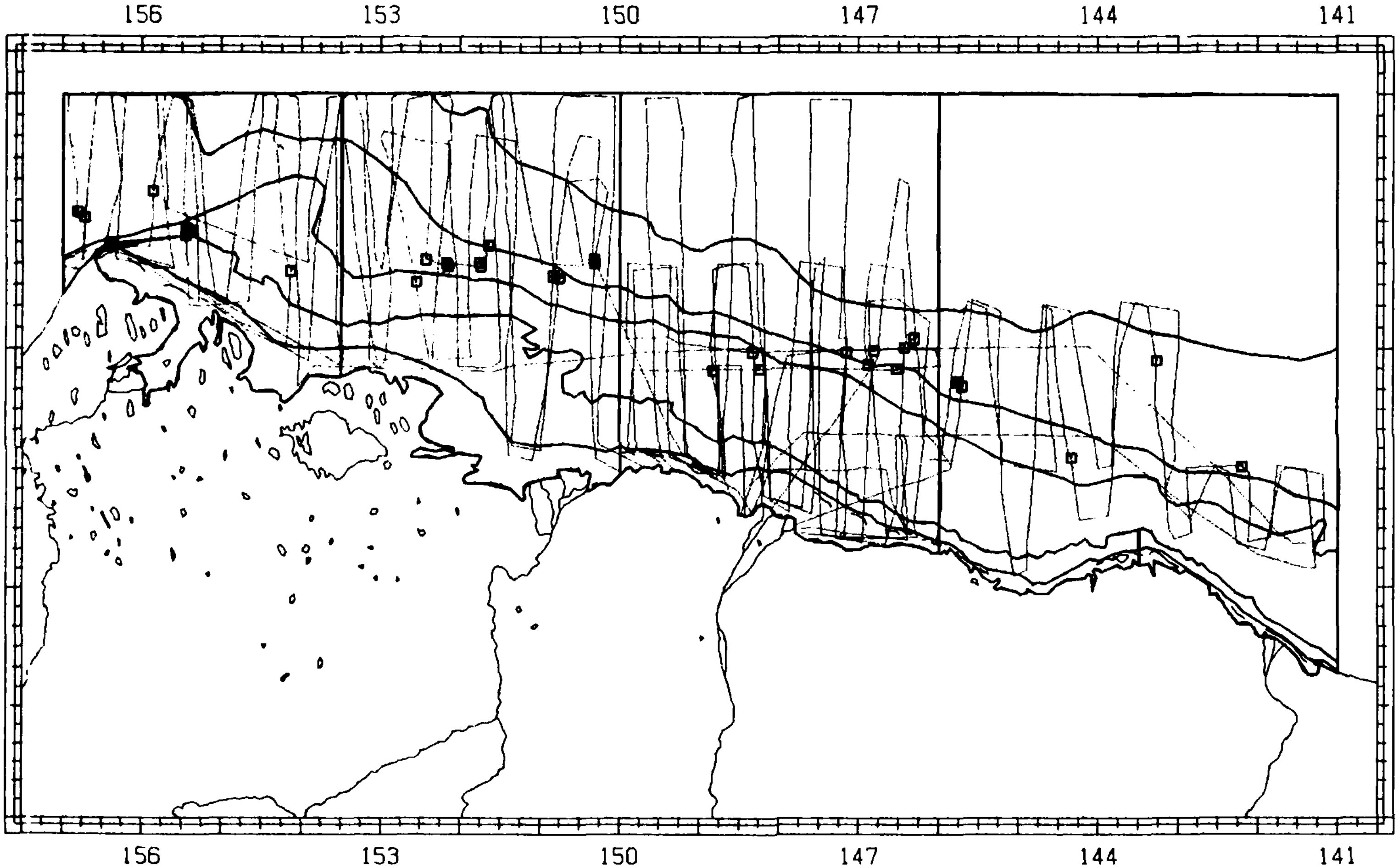

Figure B-17. Plot of aerial survey tracklines and bowhead whale sightings made during the September 16-30, 1983 aerial survey of the Beaufort Sea.

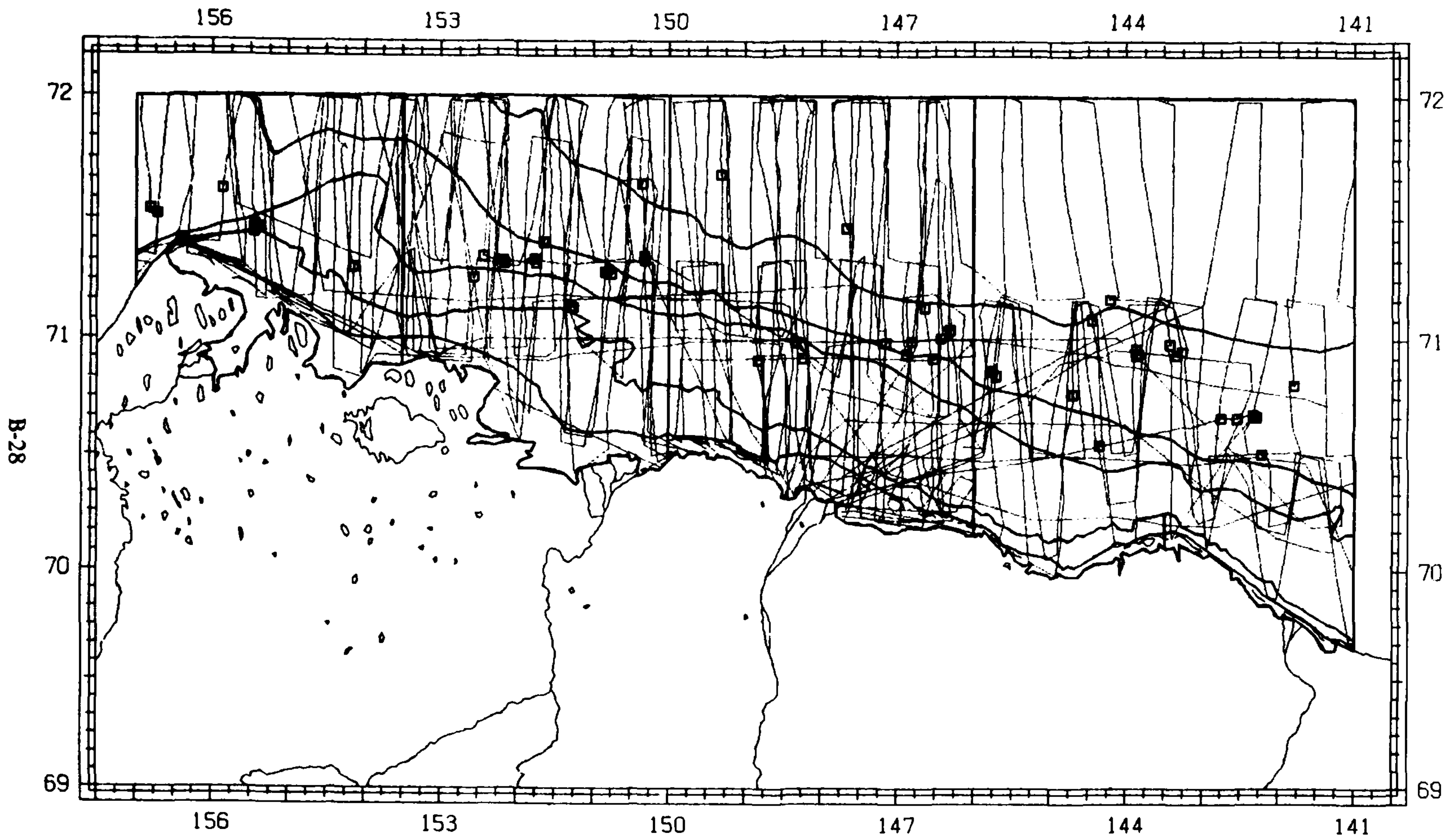

Figure B-18. Plot of aerial survey tracklines and bowhead whale sightings made during the September 1983 aerial survey of the Beaufort Sea.

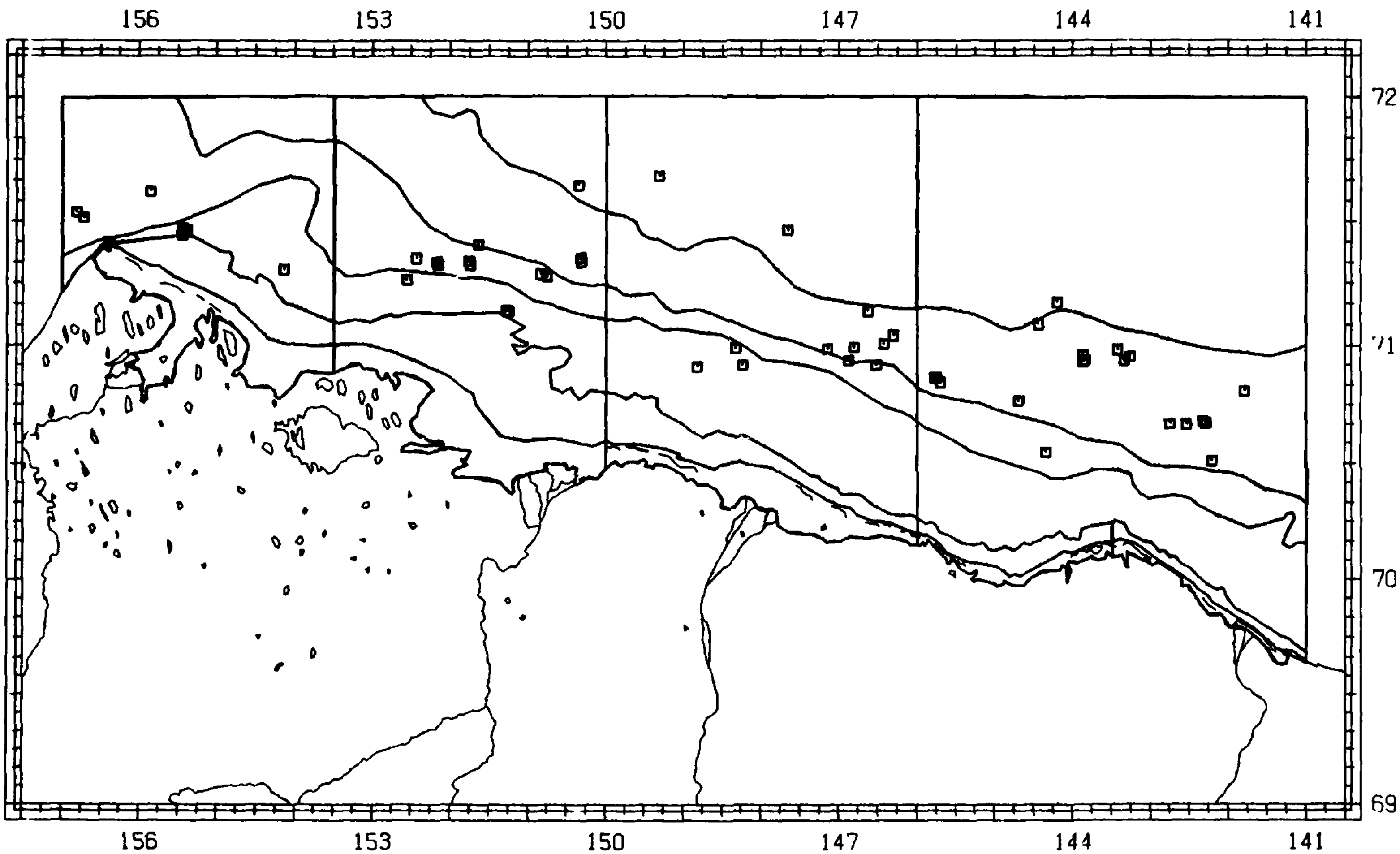

Figure B-19. Plot of bowhead whale sightings made during the September 1983 aerial survey of the Beaufort Sea.

Table B-5. Statistics from aerial surveys of bowhead whales conducted September 1983 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of sub-regions and the area calculated for the total region. Total time spent surveying was approximately 101 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Variance	Confidence Range of Density
Total	28,609	100.	46.69	100:40	100.00	443	65	0.005	>0.0	0.001 - 0.009
A	3,792	13.	45.24	13:22	13.28	75	14	0.008	0.0001	>0.0 - 0.023
A1	654	2.25	40.06	2:07	2.10	40	0	0.0	0.0	0.0 - 0.0
A2	479	1.65	63.68	2:20	2.32	35	0	0.0	0.0	0.0 - 0.0
A3	789	2.71	48.72	3:14	3.21	39	11	0.029	0.0014	>0.0 - 0.103
A4	1,518	5.22	38.54	4:22	4.34	39	3	0.005	>0.0	>0.0 - 0.014
A5	384	1.32	47.32	1:21	1.34	28	0	0.0	0.0	0.0 - 0.0
B	5,569	19.	58.66	24:53	24.72	126	21	0.006	>0.0	>0.0 - 0.018
B1	739	2.54	47.84	2:53	2.86	55	0	0.0	0.0	0.0 - 0.0
B2	1,079	3.71	51.78	4:03	4.02	44	0	0.0	0.0	0.0 - 0.0
B3	793	2.73	59.92	3:38	3.61	44	9	0.019	0.0012	>0.0 - 0.089
B4	893	3.07	71.80	5:03	5.02	63	8	0.012	0.0001	>0.0 - 0.031
B5	1,463	5.03	60.22	6:36	6.56	61	3	0.003	>0.0	>0.0 - 0.014
B6	659	2.27	53.34	2:36	2.58	37	1	0.003	>0.0	>0.0 - 0.006
C	7,701	27.	64.33	36:38	36.39	160	10	0.002	>0.0	0.001 - 0.003
C1	584	2.02	97.34	4:06	4.07	73	0	0.0	0.0	0.0 - 0.0
C2	528	1.82	61.87	2:15	2.24	57	0	0.0	0.0	0.0 - 0.0
C3	1,910	6.57	79.74	11:14	11.16	83	2	0.001	>0.0	>0.0 - 0.003
C4	486	1.67	75.25	2:55	2.90	58	2	0.005	0.0001	>0.0 - 0.026
C5	1,224	4.21	65.45	6:13	6.18	66	4	0.005	>0.0	>0.0 - 0.012
C6	3,070	10.56	44.52	9:55	9.85	64	2	0.001	>0.0	>0.0 - 0.003
D	11,625	41.	29.59	25:56	25.76	129	20	0.006	>0.0	>0.0 - 0.013
D1A	156	0.55	17.02	0:11	0.18	13	0	0.0	0.0	0.0 - 0.0
D1B	123	0.42	3.49	0:02	0.03	2	0	0.0	0.0	0.0 - 0.0
D2A	257	0.88	17.16	0:20	0.33	11	0	0.0	0.0	0.0 - 0.0
D2B	155	0.53	17.50	0:13	0.22	10	0	0.0	0.0	0.0 - 0.0
D3	1,997	6.87	32.40	4:34	4.54	58	0	0.0	0.0	0.0 - 0.0
D4	1,018	3.50	58.91	4:15	4.22	62	2	0.003	>0.0	>0.0 - 0.011
D5	2,809	9.66	46.24	10:33	10.48	68	17	0.013	0.0001	>0.0 - 0.028
D6	5,303	18.24	14.92	5:45	5.71	65	1	0.001	>0.0	>0.0 - 0.004

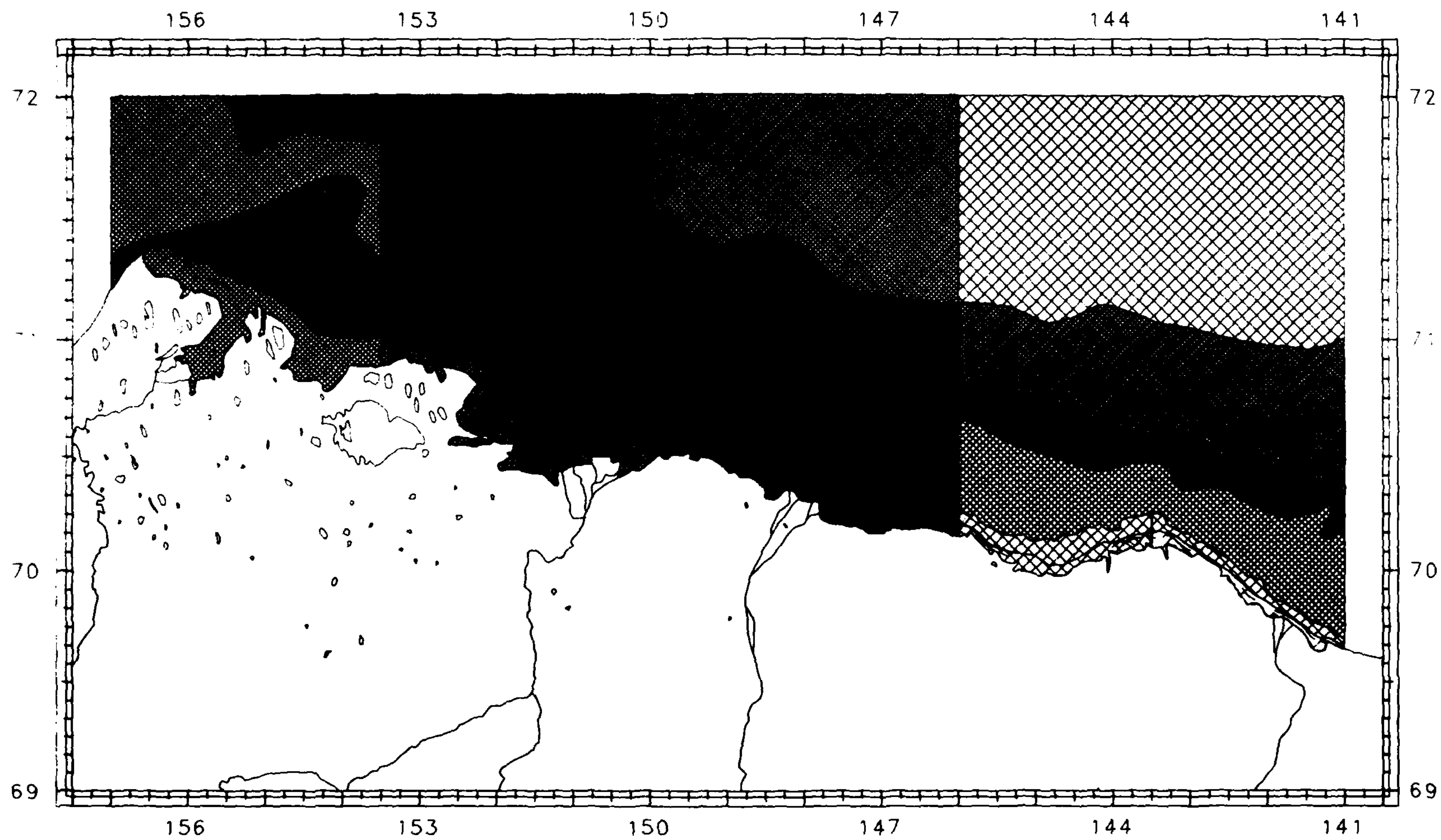

Figure B-20. Shaded regions represent percentages expressed as total number of survey track miles flown divided by the area of each region. Shading varies from all white (representing 0 percent) to all black (representing 150 percent). Data are based on the September 1983 Beaufort Sea aerial survey.

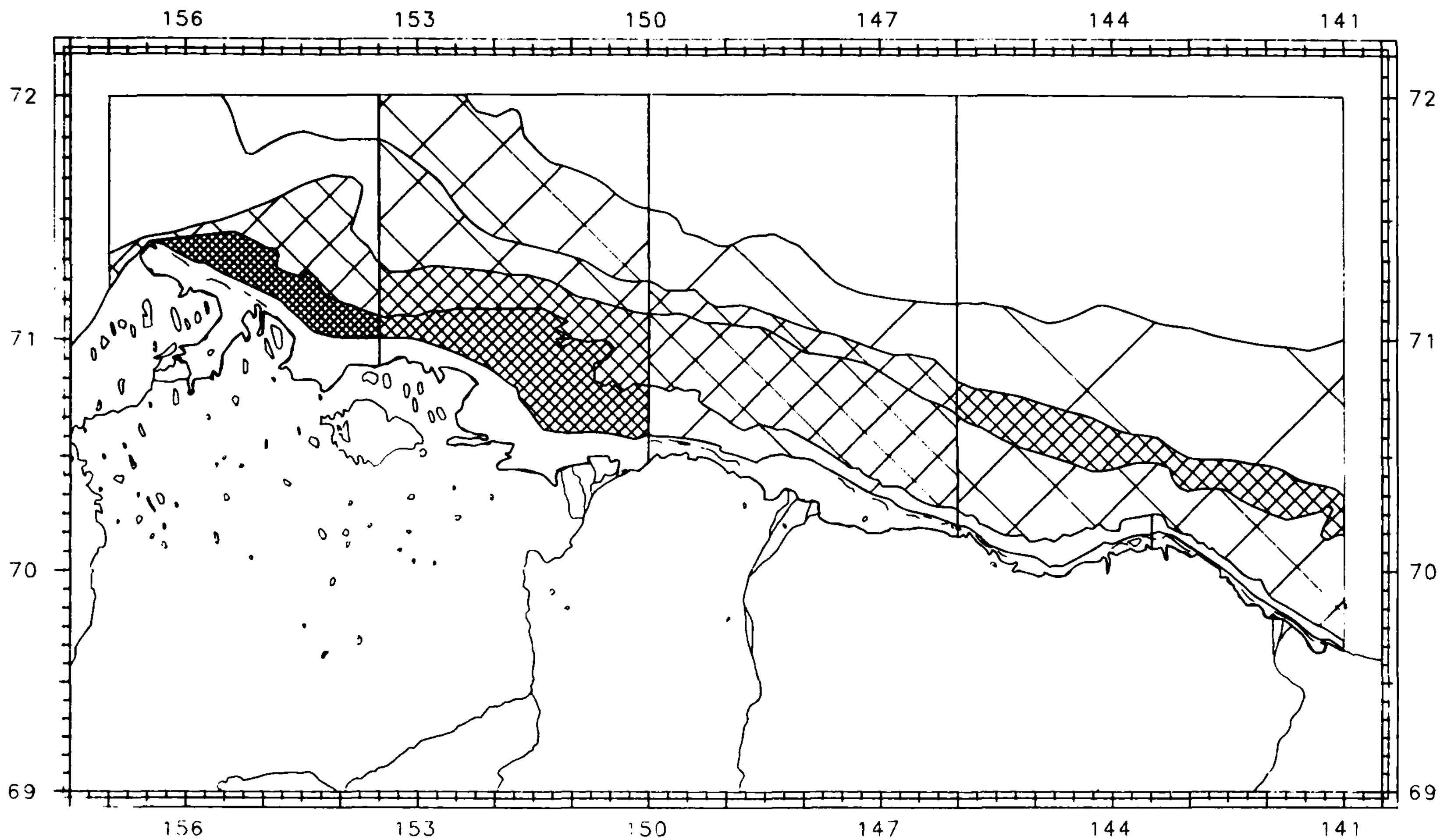

Figure B-21. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Beaufort Sea during September 1983. Shading varies from all white (representing 0 density) to all black (representing 0.110 density).

Table B-6. Statistics from aerial surveys of bowhead whales conducted September 1979-1982.

Region Name	Region Area nmi²	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi²	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi²
		1979							1980					
Total	28,609	100.	18.84	50:54	100.00	36	5	0.001	28.10	76:47	100.00	56	13	0.002
A	3,792	13.	1.58	0:30	0.98	1	0	0.0	5.88	2:10	2.82	4	0	0.0
A1	654	2.25	1.86	0:06	0.20	2	0	0.0	12.56	1:03	1.37	6	0	0.0
A2	479	1.65	7.71	0:19	0.62	2	0	0.0	15.72	0:39	0.85	7	0	0.0
A3	789	2.71	1.48	0:06	0.20	1	0	0.0	8.12	0:28	0.61	5	0	0.0
A4	1,518	5.22	0.0						0.14	0:01	0.02	3	0	0.0
A5	384	1.32	0.0						0.0					
B	5,569	19.	1.28	0:34	1.11	1	0	0.0	27.61	14:42	19.14	20	0	0.0
B1	739	2.54	0.0						47.16	5:15	6.84	30	0	0.0
B2	1,079	3.71	5.78	0:28	0.92	2	0	0.0	51.75	4:22	5.69	38	0	0.0
B3	793	2.73	1.80	0:06	0.20	2	0	0.0	40.71	2:27	3.19	36	0	0.0
B4	893	3.07	0.0						28.35	2:11	2.84	20	0	0.0
B5	1,463	5.03	0.0						4.03	0:27	0.59	4	0	0.0
B6	659	2.27	0.0						0.0					
C	7,701	27.	38.33	26:45	52.55	28	2	0.001	58.23	40:55	53.29	46	6	0.001
C1	584	2.02	139.42	8:38	16.96	58	0	0.0	190.54	11:24	14.85	92	1	0.001
C2	528	1.82	78.13	4:00	7.86	73	0	0.0	154.06	6:48	8.86	106	1	0.001
C3	1,910	6.57	72.99	11:26	22.46	48	2	0.001	111.24	19:08	24.92	75	3	0.001
C4	486	1.67	22.13	0:49	1.60	16	0	0.0	30.81	1:03	1.37	25	0	0.0
C5	1,224	4.21	14.47	1:32	3.01	9	0	0.0	12.39	1:20	1.74	8	0	0.0
C6	3,070	10.56	1.45	0:19	0.62	2	0	0.0	4.72	1:18	1.69	4	0	0.0
D	11,625	41.	19.95	23:14	45.65	22	3	0.001	15.42	19:00	24.74	31	7	0.004
D1A	156	0.55	39.70	1:14	2.42	23	0	0.0	65.06	2:26	3.17	23	1	0.010
D1B	123	0.42	24.07	0:23	0.75	6	0	0.0	83.16	2:00	2.60	20	0	0.0
D2A	257	0.88	140.52	3:18	6.48	34	1	0.003	96.88	2:13	2.89	32	0	0.0
D2B	155	0.53	47.99	0:45	1.47	17	0	0.0	78.36	3:02	3.95	21	3	0.025
D3	1,997	6.87	52.93	10:39	20.92	54	1	0.001	45.30	7:40	9.20	43	2	0.002
D4	1,018	3.50	44.12	4:16	8.38	32	0	0.0	5.93	0:29	0.63	6	0	0.0
D5	2,809	9.66	10.41	2:38	5.17	11	1	0.003	5.55	1:10	1.52	4	0	0.0
D6	5,303	18.24	0.0						1.78	0:34	0.74	2	0	0.0
		1981							1982					
Total	28,609	100.	25.23	57:45	100.00	99	158	0.022	29.30	65:05	100.00	288	120	0.014
A	3,792	13.	1.48	0:24	0.69	6	0	0.0	20.81	6:44	10.35	37	3	0.004
A1	654	2.25	0.98	0:03	0.09	3	0	0.0	23.84	2:07	3.25	20	0	0.0
A2	479	1.65	3.02	0:06	0.17	2	0	0.0	33.80	1:03	1.61	19	1	0.006
A3	789	2.71	4.38	0:15	0.43	5	0	0.0	31.85	1:45	2.69	24	0	0.0
A4	1,518	5.22	0.06	0:00	0.00	1	0	0.0	13.44	1:40	2.56	24	2	0.010
A5	384	1.32	0.0						4.43	0:09	0.23	3	0	0.0
B	5,569	19.	12.49	4:50	8.37	25	0	0.0	43.90	18:03	27.73	86	7	0.003
B1	739	2.54	5.26	0:16	0.46	9	0	0.0	52.93	2:53	4.43	50	0	0.0
B2	1,079	3.71	27.66	2:02	3.52	25	0	0.0	68.27	5:35	8.58	66	4	0.005
B3	793	2.73	27.82	1:35	2.74	25	0	0.0	63.41	3:42	5.69	60	2	0.004
B4	893	3.07	13.00	0:49	1.41	17	0	0.0	46.94	3:08	4.81	48	1	0.002
B5	1,463	5.03	1.41	0:08	0.23	4	0	0.0	22.95	2:21	3.61	33	0	0.0
B6	659	2.27	0.0						8.49	0:24	0.61	7	0	0.0
C	7,701	27.	36.14	19:28	33.71	83	5	0.002	19.01	11:06	17.06	63	58	0.040
C1	584	2.02	112.97	4:40	8.08	71	0	0.0	60.77	2:33	3.92	46	0	0.0
C2	528	1.82	148.46	5:31	9.55	84	0	0.0	46.59	1:45	2.69	33	1	0.004
C3	1,910	6.57	86.92	8:52	5.35	72	5	0.004	37.58	5:34	8.55	42	56	0.078
C4	486	1.67	11.13	0:22	0.63	13	0	0.0	20.85	0:48	1.23	19	1	0.010
C5	1,224	4.21	0.37	0:02	0.06	2	0	0.0	6.54	0:38	0.97	12	0	0.0
C6	3,070	10.56	0.0						0.46	0:07	0.18	3	0	0.0
D	11,625	41.	31.59	32:57	57.06	33	153	0.042	30.97	28:43	44.12	123	52	0.014
D1A	156	0.55	75.12	0:54	1.56	19	0	0.0	38.50	0:39	1.00	16	0	0.0
D1B	123	0.42	71.77	0:40	1.15	18	0	0.0	65.79	0:57	1.46	20	0	0.0
D2A	257	0.88	121.26	2:19	4.01	42	0	0.0	46.16	0:53	1.36	22	0	0.0
D2B	155	0.53	152.46	2:06	3.64	33	5	0.027	101.45	1:25	2.18	28	0	0.0
D3	1,997	6.87	114.76	22:07	38.30	71	145	0.063	59.77	10:25	16.01	68	48	0.040
D4	1,018	3.50	9.21	0:46	1.33	12	1	0.011	46.39	3:17	5.04	51	0	0.0
D5	2,809	9.66	11.81	2:42	4.68	4	0	0.0	28.64	5:46	8.86	51	0	0.0
D6	5,303	18.24	3.99	1:29	2.57	3	0	0.0	13.55	5:30	8.45	43	4	0.006

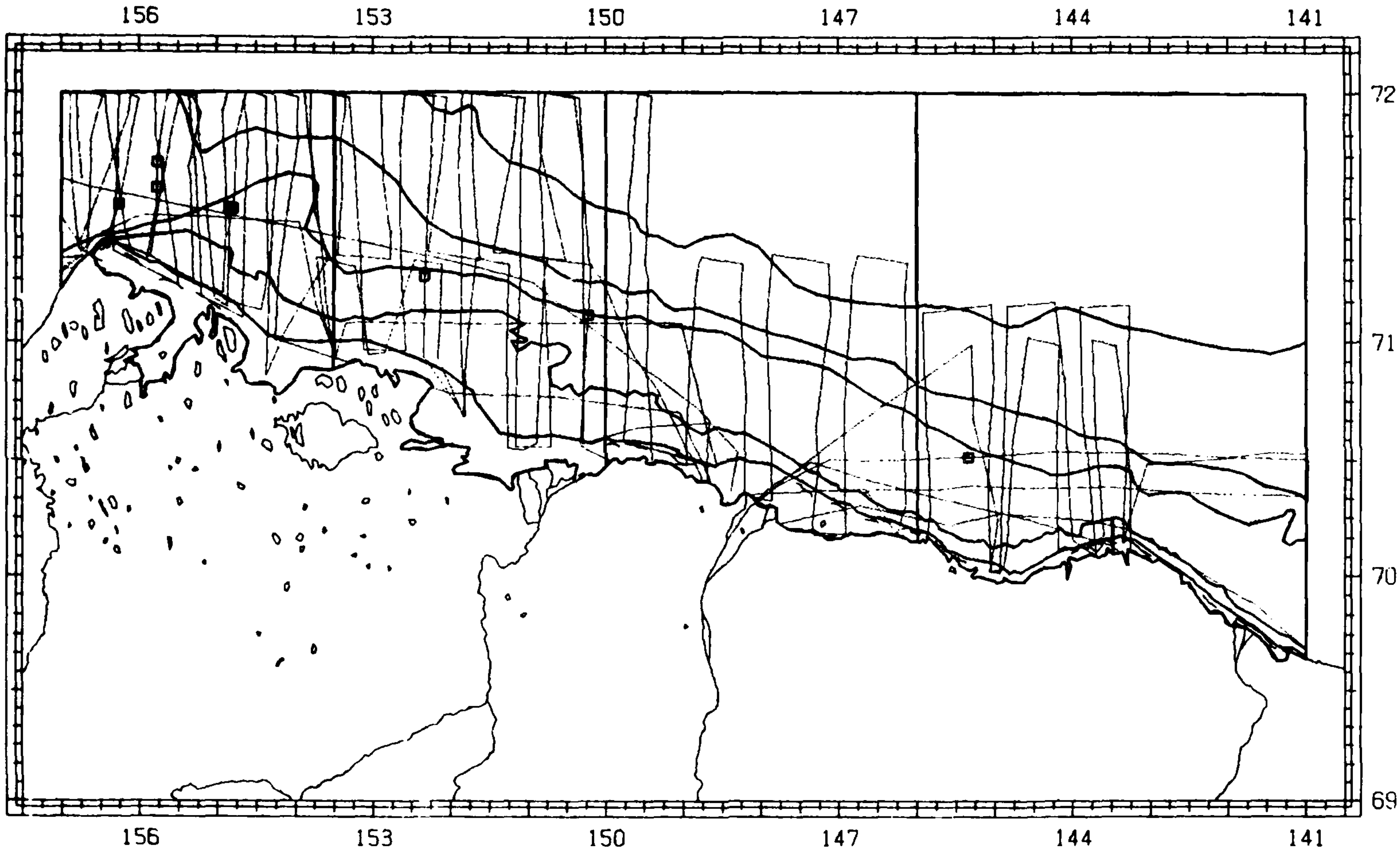

Figure B-22. Plot of aerial survey tracklines and bowhead whale sightings made during the October 1-15, 1983 aerial survey of the Beaufort Sea.

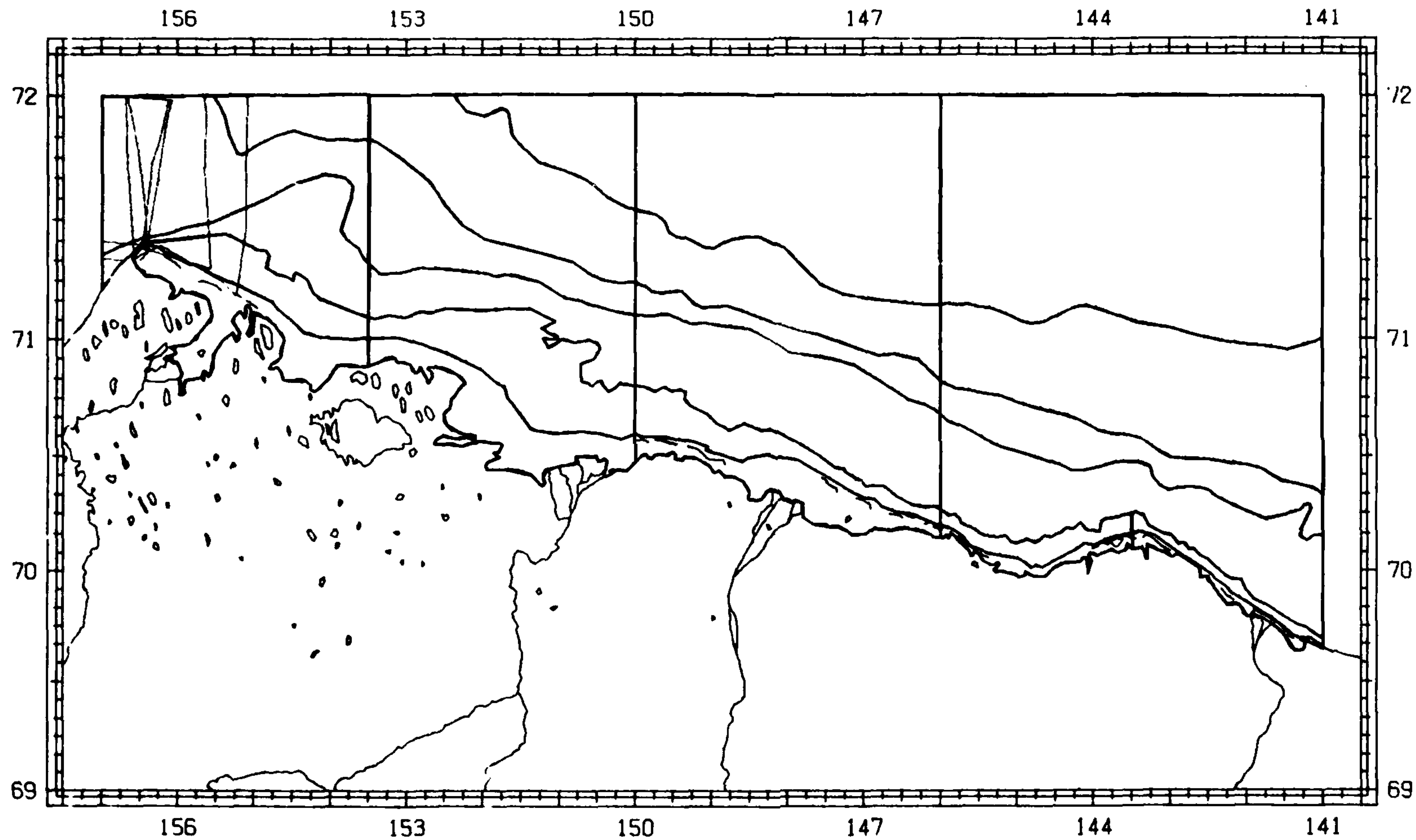

Figure B-23. Plot of aerial survey tracklines and bowhead whale sightings made during the October 16–31, 1983 aerial survey of the Beaufort Sea.

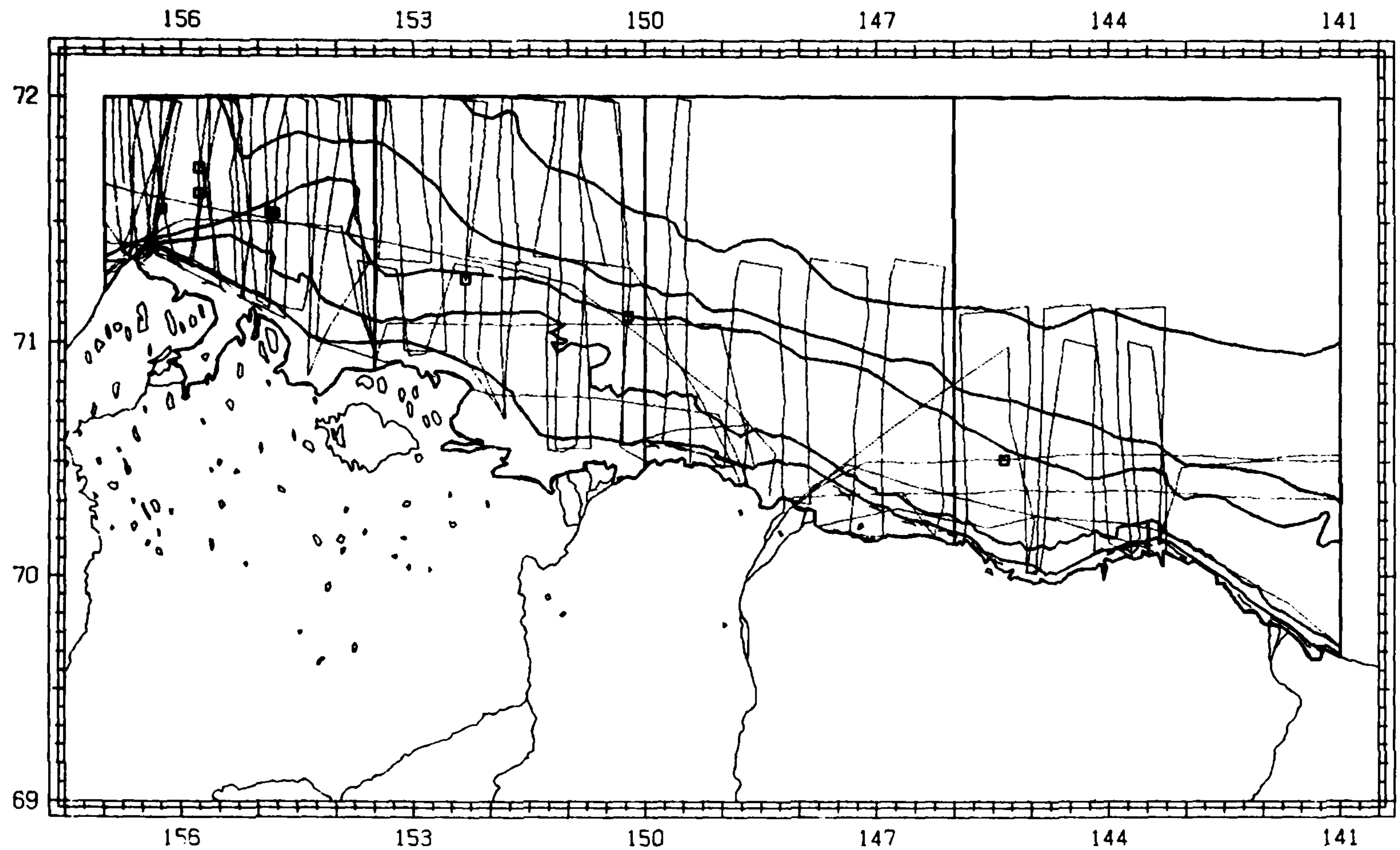

Figure B-24. Plot of aerial survey tracklines and bowhead whale sightings made during the October 1983 aerial survey of the Beaufort Sea.

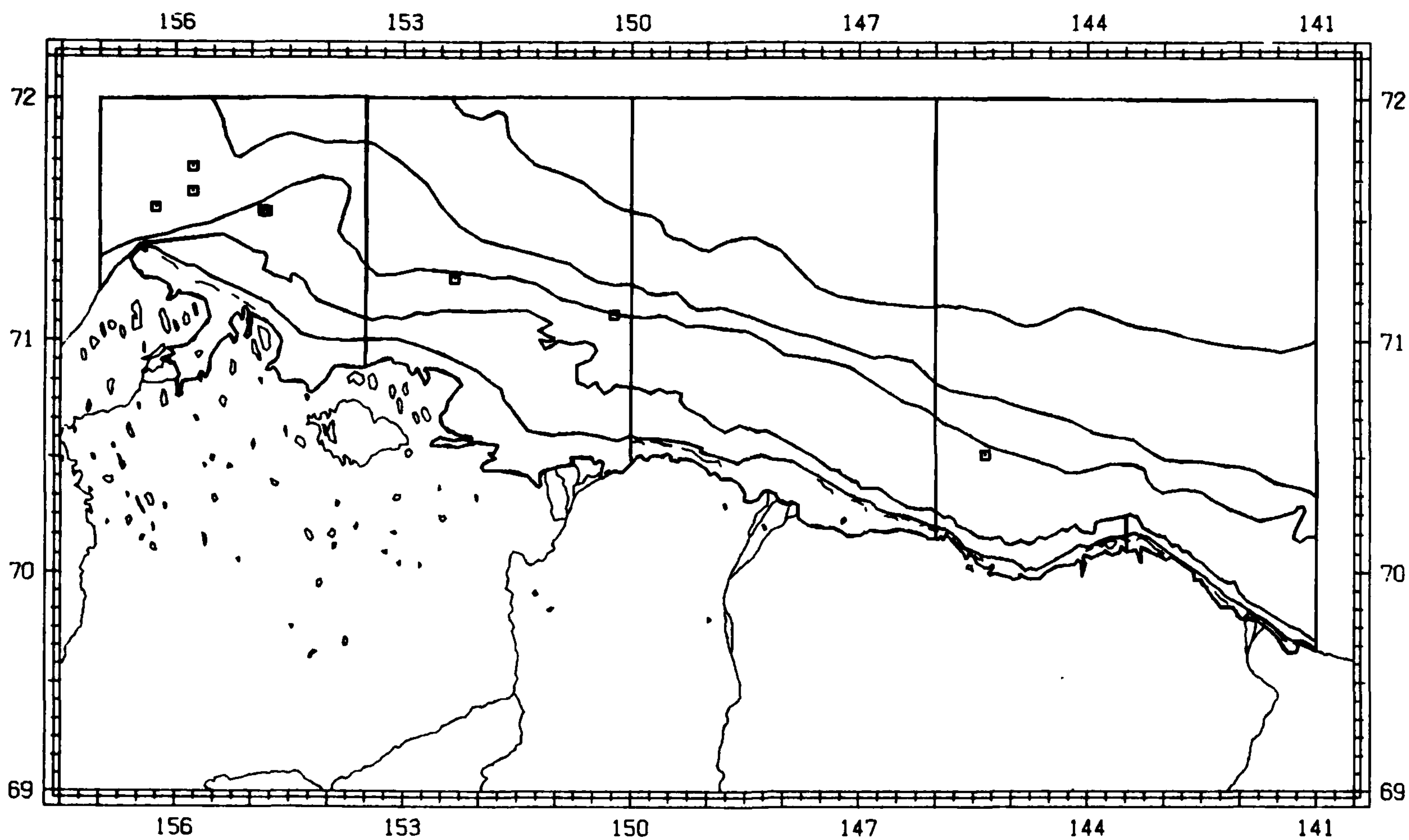

Figure B-25. Plot of bowhead whale sightings made during the October 1983 aerial survey of the Beaufort Sea.

Table B-7. Statistics from aerial surveys of bowhead whales conducted October 1983 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of sub-regions and the area calculated for the total region. Total time spent surveying was approximately 39 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Variance	Confidence Range of Density
Total	28,609	100.	18.87	39:15	100.00	156	12	0.002	>0.0	>0.0 - 0.006
A	3,792	13.	43.78	12:11	31.04	67	8	0.005	>0.0	>0.0 - 0.016
A1	654	2.25	20.67	1:00	2.55	30	0	0.0	0.0	0.0 - 0.0
A2	479	1.65	50.24	1:49	4.63	32	0	0.0	0.0	0.0 - 0.0
A3	789	2.71	43.77	2:34	6.54	41	6	0.017	0.0005	>0.0 - 0.062
A4	1,518	5.22	51.15	5:37	14.31	43	2	0.003	>0.0	>0.0 - 0.005
A5	384	1.32	42.49	1:11	3.01	22	0	0.0	0.0	0.0 - 0.0
B	5,569	19.	26.47	10:31	26.79	54	3	0.002	>0.0	>0.0 - 0.004
B1	739	2.54	17.69	0:56	2.38	27	0	0.0	0.0	0.0 - 0.0
B2	1,079	3.71	28.83	2:09	5.48	22	0	0.0	0.0	0.0 - 0.0
B3	793	2.73	24.67	1:21	3.44	18	3	0.015	0.0001	>0.0 - 0.034
B4	893	3.07	33.69	2:16	5.77	27	0	0.0	0.0	0.0 - 0.0
B5	1,463	5.03	24.32	2:32	6.45	23	0	0.0	0.0	0.0 - 0.0
B6	659	2.27	26.96	1:17	3.27	16	0	0.0	0.0	0.0 - 0.0
C	7,701	27.	14.26	8:16	21.06	29	0	0.0	0.0	0.0 - 0.0
C1	584	2.02	29.11	1:36	4.08	23	0	0.0	0.0	0.0 - 0.0
C2	528	1.82	34.31	1:18	3.31	22	0	0.0	0.0	0.0 - 0.0
C3	1,910	6.57	22.05	3:00	7.64	19	0	0.0	0.0	0.0 - 0.0
C4	486	1.67	14.81	0:30	1.27	11	0	0.0	0.0	0.0 - 0.0
C5	1,224	4.21	10.68	0:58	2.46	10	0	0.0	0.0	0.0 - 0.0
C6	3,070	10.56	4.01	0:55	2.34	9	0	0.0	0.0	0.0 - 0.0
D	11,625	41.	10.19	8:24	21.40	30	1	0.001	>0.0	>0.0 - 0.002
D1A	156	0.55	24.19	0:16	0.68	13	0	0.0	0.0	0.0 - 0.0
D1B	123	0.42	8.37	0:06	0.25	5	0	0.0	0.0	0.0 - 0.0
D2A	257	0.88	23.29	0:26	1.10	17	0	0.0	0.0	0.0 - 0.0
D2B	155	0.53	17.01	0:11	0.47	8	0	0.0	0.0	0.0 - 0.0
D3	1,997	6.87	20.96	3:05	7.86	26	1	0.002	>0.0	>0.0 - 0.009
D4	1,018	3.50	20.04	1:24	3.57	14	0	0.0	0.0	0.0 - 0.0
D5	2,809	9.66	13.45	2:35	6.58	18	0	0.0	0.0	0.0 - 0.0
D6	5,303	18.24	0.93	0:20	0.85	8	0	0.0	0.0	0.0 - 0.0

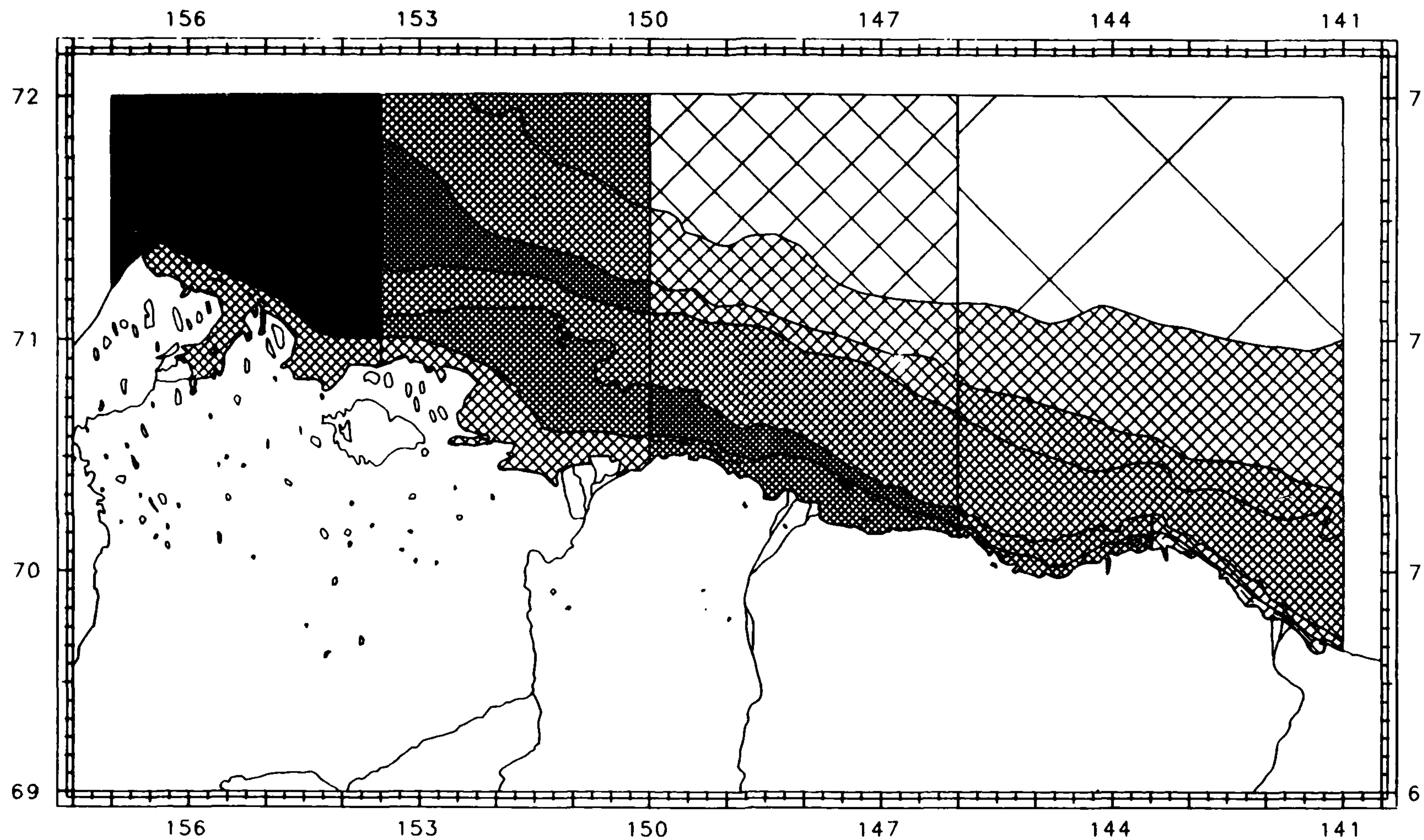

Figure B-26. Shaded regions represent percentages expressed as total number of survey track miles flown divided by the area of each region. Shading varies from all white (representing 0 percent) to all black (representing 150 percent). Data are based on the October 1983 Beaufort Sea aerial survey.

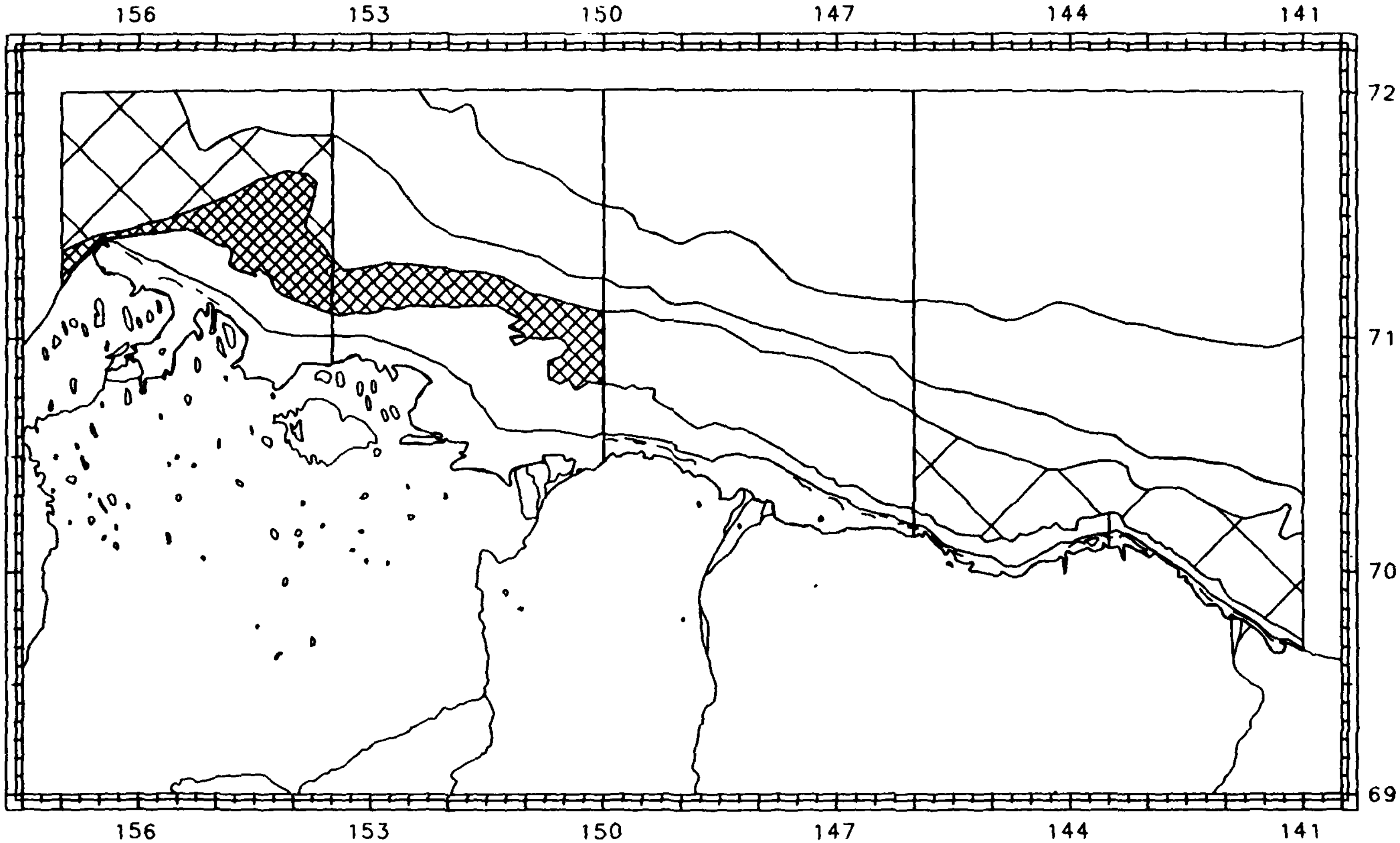

Figure B-27. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Beaufort Sea *during October* 1983. Shading varies from all white (representing 0 density) to all black (representing 0.110 density).

Table B-8. Statistics from aerial surveys of bowhead whales conducted October 1979-1982.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2
			1979						1980					
Total	28,609	100.	24.02	81:54	100.00	39	145	0.021	22.24	50:20	100.00	30	8	0.001
A	3,792	13.	19.33	8:14	10.05	15	5	0.007	14.06	4:21	8.64	11	0	0.0
A1	654	2.25	6.59	0:35	0.71	9	0	0.0	13.12	0:45	1.49	9	0	0.0
A2	479	1.65	18.86	1:02	1.26	7	0	0.0	18.75	0:41	1.36	11	0	0.0
A3	789	2.71	26.99	2:04	2.52	14	1	0.005	32.01	2:02	4.04	14	0	0.0
A4	1,518	5.22	22.71	4:06	5.01	15	4	0.012	7.15	0:55	1.82	10	0	0.0
A5	384	1.32	10.68	0:26	0.53	4	0	0.0	0.0					
B	5,569	19.	11.84	7:12	8.79	7	41	0.062	44.80	19:56	39.60	30	4	0.002
B1	739	2.54	0.64	0:02	0.04	2	0	0.0	74.43	5:21	10.63	45	0	0.0
B2	1,079	3.71	23.54	2:24	2.93	14	0	0.0	81.18	6:22	12.65	65	0	0.0
B3	793	2.73	30.52	2:55	3.56	20	41	0.169	75.15	4:23	8.71	64	4	0.007
B4	893	3.07	10.51	0:47	0.96	7	0	0.0	41.84	3:04	6.09	30	0	0.0
B5	1,463	5.03	4.45	1:03	1.28	2	0	0.0	8.55	0:54	1.79	6	0	0.0
B6	659	2.27	0.0						0.0					
C	7,701	27.	62.93	59:51	73.08	58	81	0.017	34.38	20:45	41.23	24	4	0.002
C1	584	2.02	258.45	17:11	20.98	98	0	0.0	94.01	4:47	9.50	42	0	0.0
C2	528	1.82	139.58	8:03	9.83	129	6	0.008	79.70	3:21	6.66	70	0	0.0
C3	1,910	6.57	119.69	31:19	38.24	81	75	0.033	77.48	11:15	22.35	53	4	0.003
C4	486	1.67	23.31	1:05	1.32	18	0	0.0	22.51	0:46	1.52	12	0	0.0
C5	1,224	4.21	19.97	2:30	3.05	14	0	0.0	5.54	0:29	0.96	4	0	0.0
C6	3,070	10.56	2.52	0:45	0.92	4	0	0.0	0.76	0:09	0.30	1	0	0.0
D	11,625	41.	5.65	6:49	8.32	21	18	0.027	5.92	5:09	10.23	8	0	0.0
D1A	156	0.55	3.98	0:04	0.08	3	0	0.0	4.96	0:05	0.17	3	0	0.0
D1B	123	0.42	0.0						0.0					
D2A	257	0.88	46.27	1:09	1.40	17	0	0.0	32.94	0:44	1.46	12	0	0.0
D2B	155	0.53	0.0						42.15	0:31	1.03	11	0	0.0
D3	1,997	6.87	16.11	3:44	4.56	23	18	0.056	26.12	3:45	7.45	19	0	0.0
D4	1,018	3.50	8.54	0:49	1.00	6	0	0.0	0.81	0:05	0.17	1	0	0.0
D5	2,809	9.66	1.03	0:14	0.28	2	0	0.0	0.0					
D6	5,303	18.24	0.02	0:01	0.02	1	0	0.0	0.0					
			1981						1982					
Total	28,609	100.	17.70	41:44	100.00	160	46	0.009	14.91	30:20	100.00	162	25	0.006
A	3,792	13.	4.92	1:26	3.43	11	0	0.0	32.04	8:38	28.46	57	11	0.009
A1	654	2.25	12.34	0:35	1.40	7	0	0.0	15.23	0:42	2.31	23	4	0.040
A2	479	1.65	11.74	0:28	1.12	7	0	0.0	39.58	1:16	4.18	22	4	0.021
A3	789	2.71	6.39	0:23	0.92	8	0	0.0	37.33	2:00	6.59	34	1	0.003
A4	1,518	5.22	0.0						34.40	3:53	12.80	37	2	0.004
A5	384	1.32	0.0						28.09	0:46	2.53	16	0	0.0
B	5,569	19.	30.14	12:33	30.07	64	8	0.005	18.17	7:18	24.07	44	10	0.010
B1	739	2.54	34.01	1:51	4.43	38	0	0.0	7.02	0:24	1.32	8	0	0.0
B2	1,079	3.71	65.23	5:00	11.98	53	0	0.0	12.39	0:53	2.91	9	2	0.015
B3	793	2.73	59.32	3:46	9.03	52	8	0.017	12.57	0:40	2.20	9	7	0.070
B4	893	3.07	21.86	1:28	3.51	38	0	0.0	24.41	1:38	5.38	28	0	0.0
B5	1,463	5.03	3.85	0:28	1.12	12	0	0.0	22.84	2:28	8.13	22	1	0.003
B6	659	2.27	0.0						27.23	1:18	4.29	13	0	0.0
C	7,701	27.	24.84	15:42	37.62	81	16	0.008	12.18	6:24	21.10	36	1	0.001
C1	584	2.02	50.89	2:06	5.03	52	0	0.0	25.16	0:53	2.91	17	0	0.0
C2	528	1.82	67.71	2:55	6.99	57	1	0.003	26.33	0:56	3.08	20	0	0.0
C3	1,910	6.57	58.35	9:39	23.12	60	14	0.013	25.82	3:22	11.10	24	1	0.002
C4	486	1.67	28.93	1:01	2.44	28	1	0.007	9.08	0:20	1.10	12	0	0.0
C5	1,224	4.21	0.53	0:03	0.12	5	0	0.0	6.07	0:38	2.09	4	0	0.0
C6	3,070	10.56	0.0						1.18	0:13	0.71	1	0	0.0
D	11,625	41.	11.16	12:06	28.99	40	22	0.017	9.52	8:06	26.70	39	3	0.003
D1A	156	0.55	6.26	0:05	0.20	5	0	0.0	14.81	0:12	0.66	13	0	0.0
D1B	123	0.42	35.17	0:18	0.72	6	0	0.0	9.20	0:06	0.33	4	0	0.0
D2A	257	0.88	36.71	0:40	1.60	20	0	0.0	28.50	0:32	1.76	15	0	0.0
D2B	155	0.53	36.65	0:25	1.00	12	0	0.0	15.55	0:13	0.71	9	0	0.0
D3	1,997	6.87	31.99	7:23	17.69	34	22	0.034	27.87	3:52	12.75	27	3	0.005
D4	1,018	3.50	13.09	0:57	2.28	16	0	0.0	13.89	1:01	3.35	20	0	0.0
D5	2,809	9.66	10.61	2:09	5.15	19	0	0.0	4.14	0:49	2.69	9	0	0.0
D6	5,303	18.24	0.28	0:06	0.24	5	0	0.0	3.01	1:20	4.40	4	0	0.0

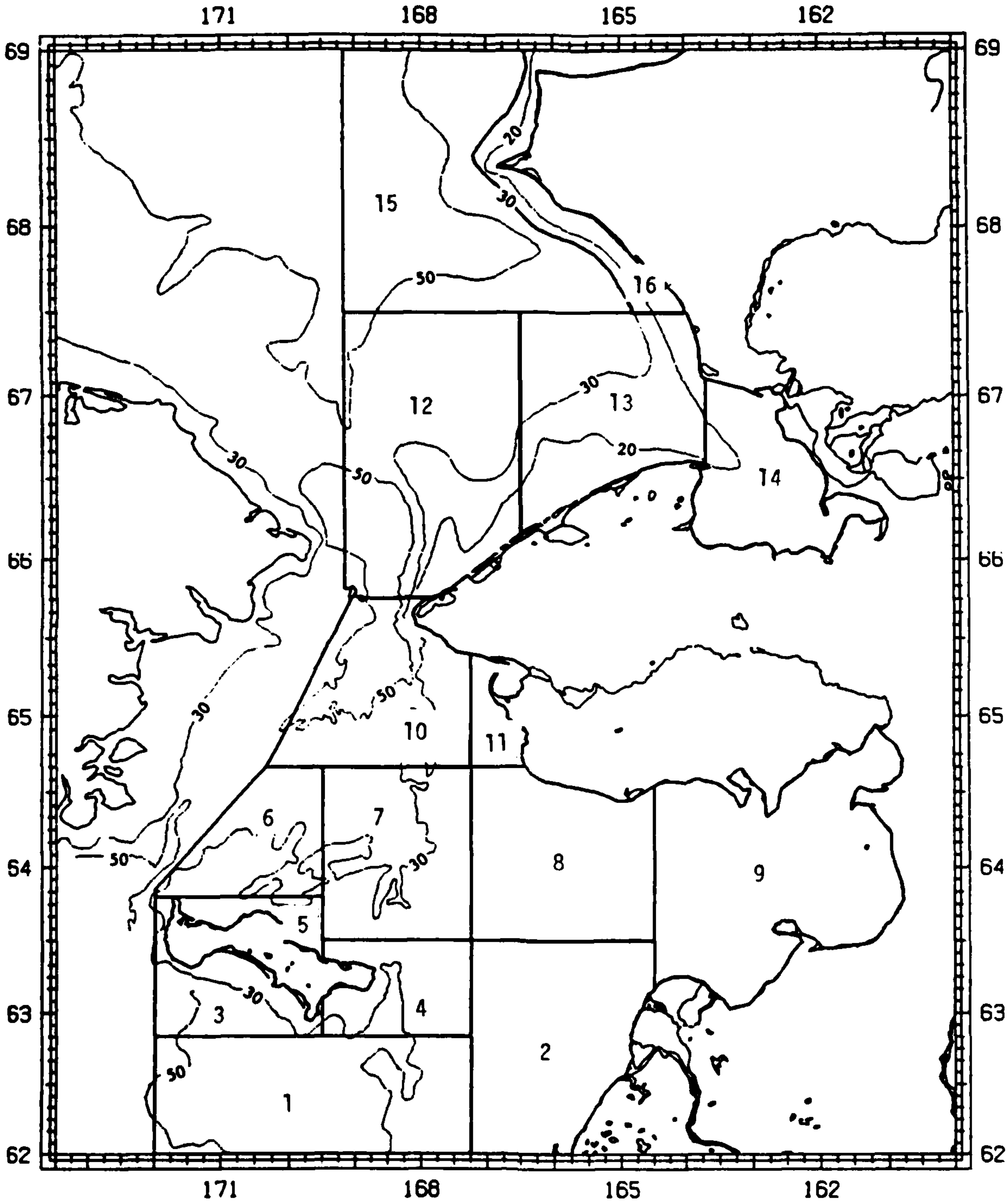

Figure B-28. Map depicting survey areas in relation to depth contours in the Bering and Chukchi Sea.

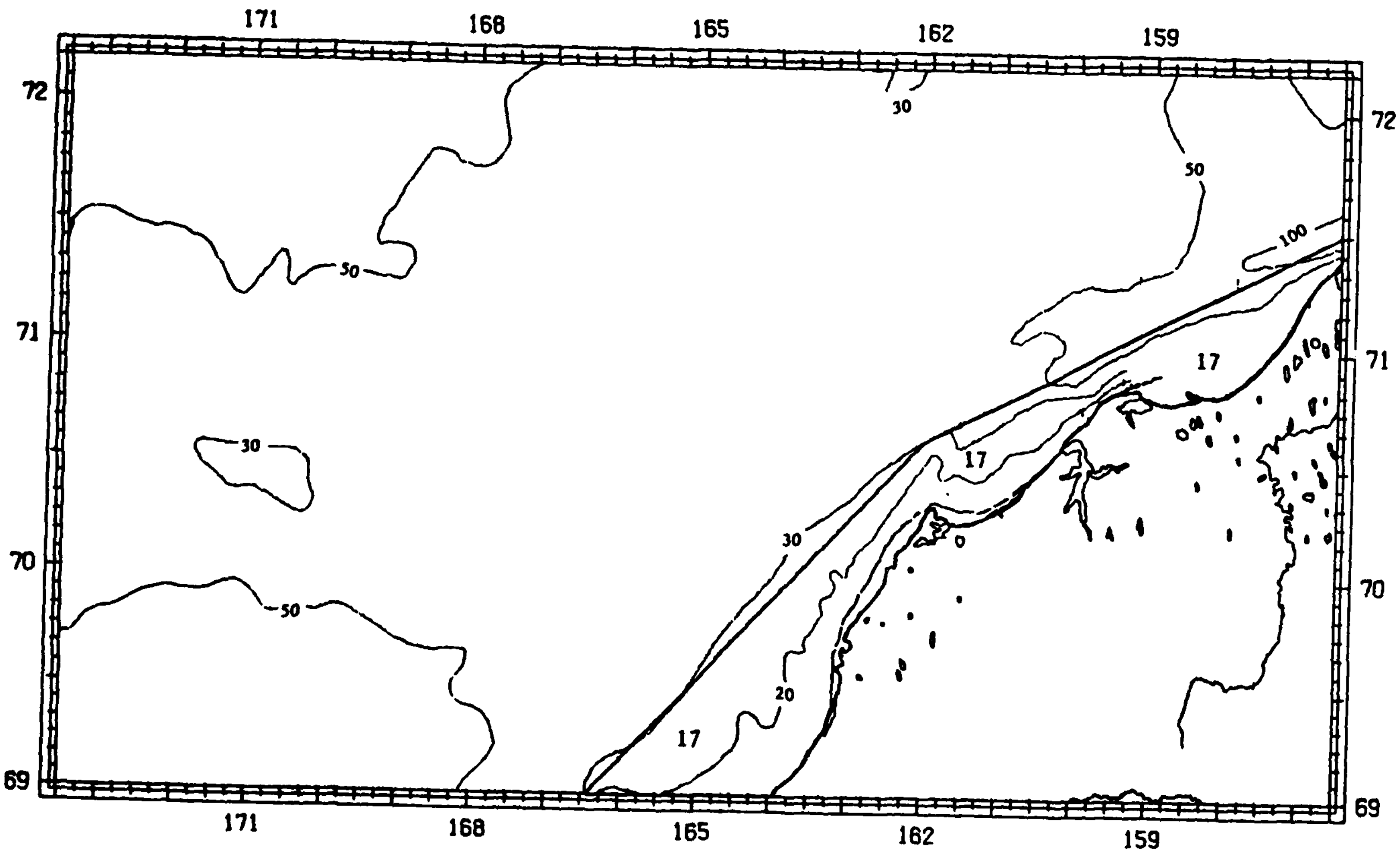

Figure B-29. Map depicting the survey area 17 in relation to depth contours in the Chukchi Sea.

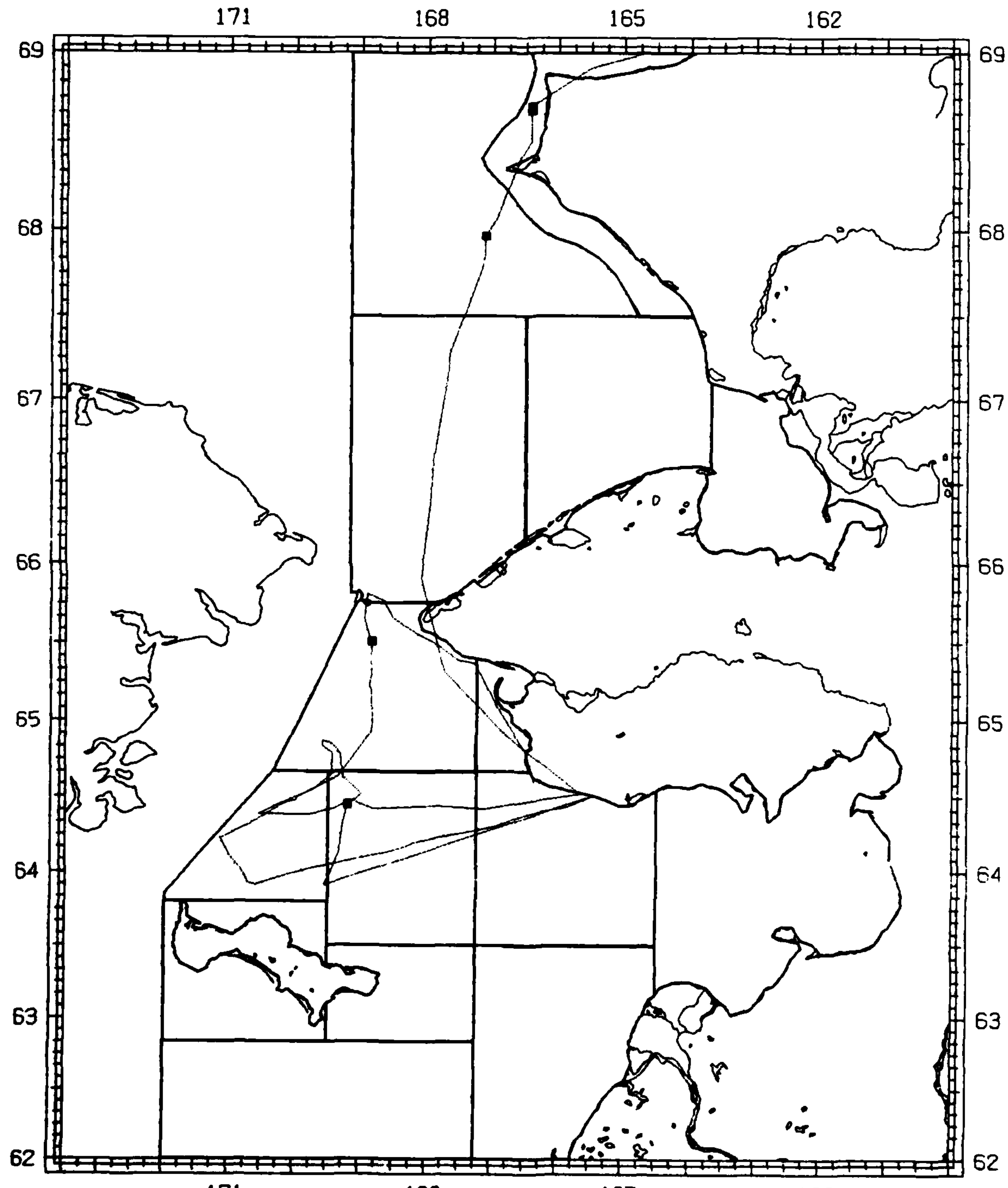

Figure B-30. Plot of aerial survey tracklines flown during April–May 1983 in the Bering and Chukchi Seas, regions 1–16. Squares represent bowhead whale sightings.

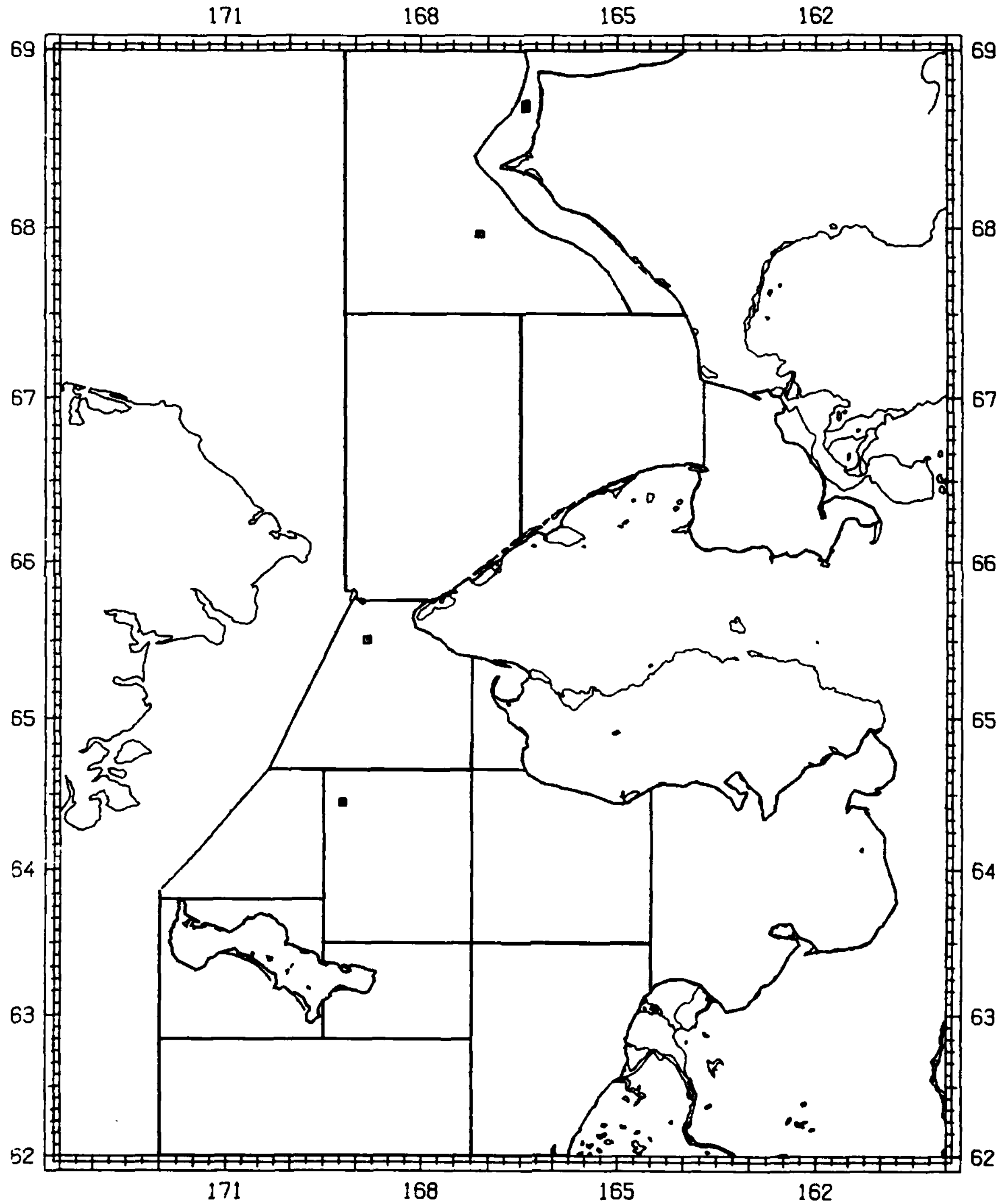

Figure B-31. Plot of bowhead whale sightings made during the April–May 1983 aerial survey of the Chukchi and Bering Seas, regions 1–16.

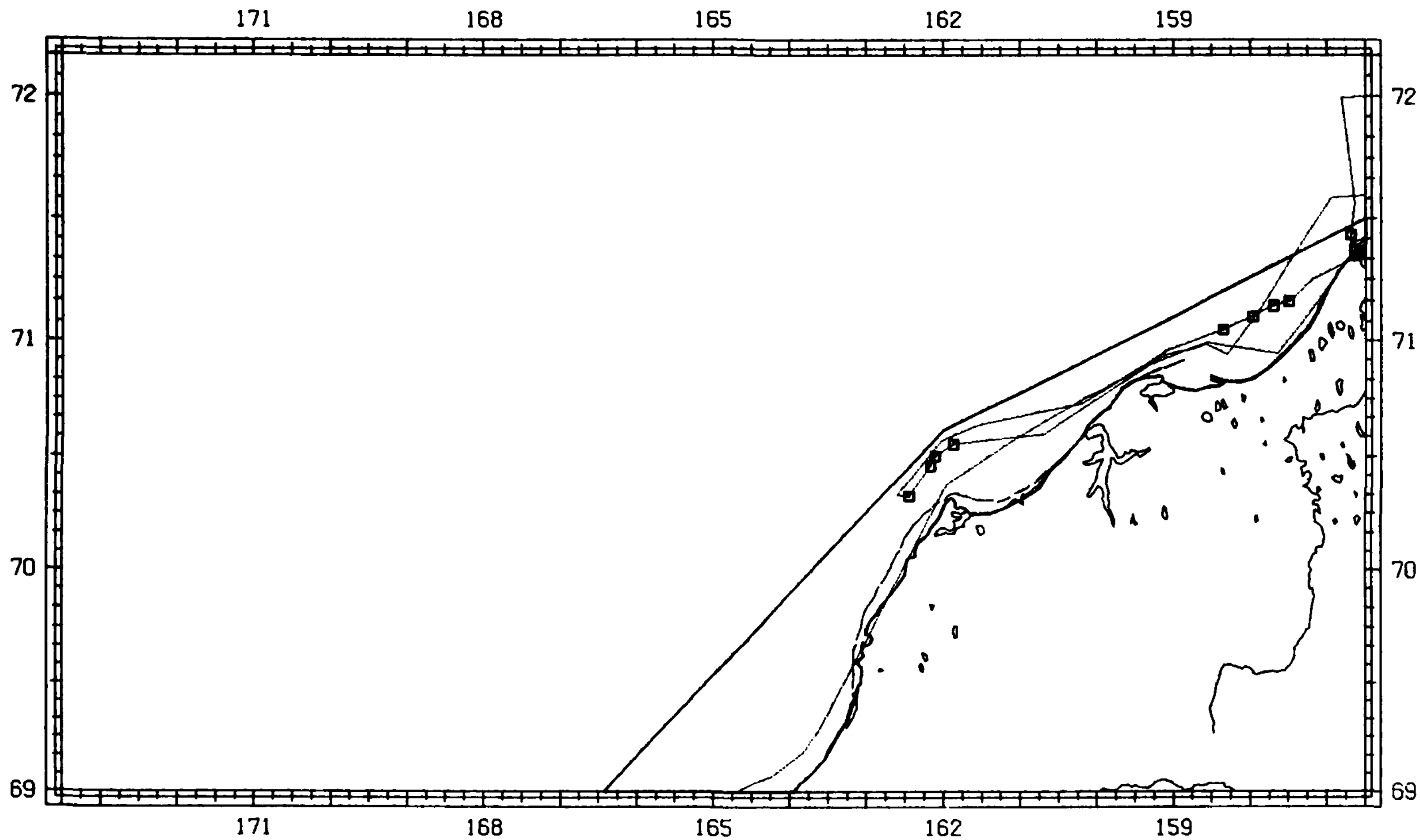

Figure B-32. Plot of aerial survey tracklines flown during April–May 1983 in the Chukchi Sea, region 17. Squares represent bowhead whale sightings.

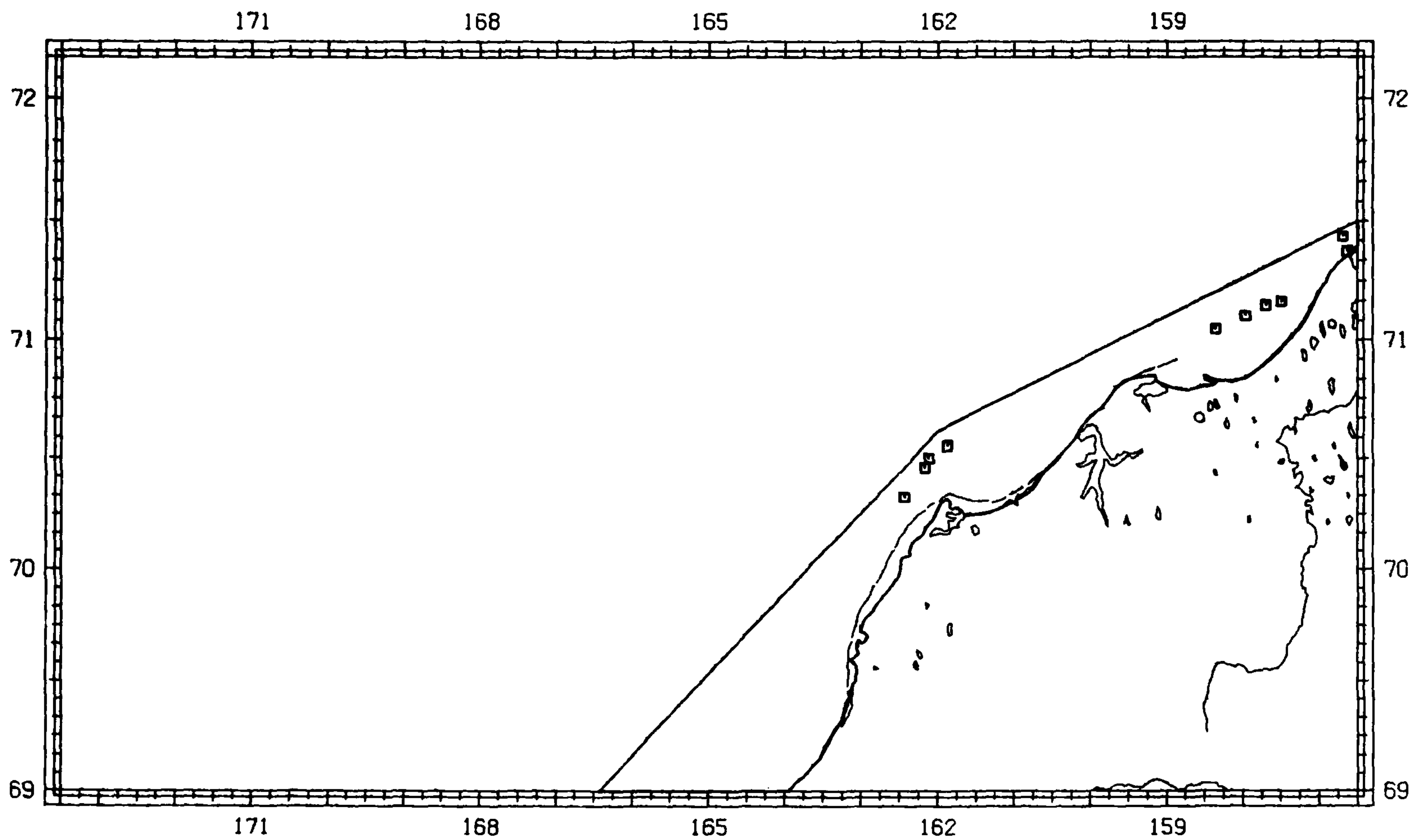

Figure B-33. Plot of bowhead whale sightings made during the April–May 1983 aerial survey of the Chukchi Sea, region 17.

Table B-9. Statistics from aerial surveys of bowhead whales conducted April-May 1983 in the Bering and Chukchi Seas. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-28. The total area of all regions was approximately 64,871 nmi^2. Total time spent surveying was approximately 10 hours and 34 minutes.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
1	6,542	10.08	0.0							
2	5,550	8.56	0.0							
3	2,011	3.10	0.0							
4	2,211	3.41	0.0							
5	724	1.12	0.0							
6	2,313	3.56	7.15	1:17	12.15	3	0	0.0	0.0	0.0 - 0.0
7	4,088	6.30	5.93	1:58	18.61	6	2	0.008	0.5	>0.0 - 0.027
8	4,566	7.04	2.48	0:45	7.10	4	0	0.0	0.0	0.0 - 0.0
9	7,262	11.19	0.0							
10	3,676	5.67	4.83	1:21	12.78	5	1	0.006	0.1	>0.0 - 0.015
11	767	1.18	5.17	0:22	3.47	1	0	0.0		
12	6,185	9.53	1.89	0:41	6.47	2	0	0.0	0.0	0.0 - 0.0
13	4,140	6.38	0.0							
14	2,469	3.81	0.0							
15	5,767	8.89	0.81	0:16	2.52	1	1	0.021		
16	1,504	2.32	3.85	0:28	4.42	3	10	0.173	175.6	>0.0 - 0.743
17	5,096	7.86	9.61	3:26	32.48	8	11	0.022	1.4	>0.0 - 0.051

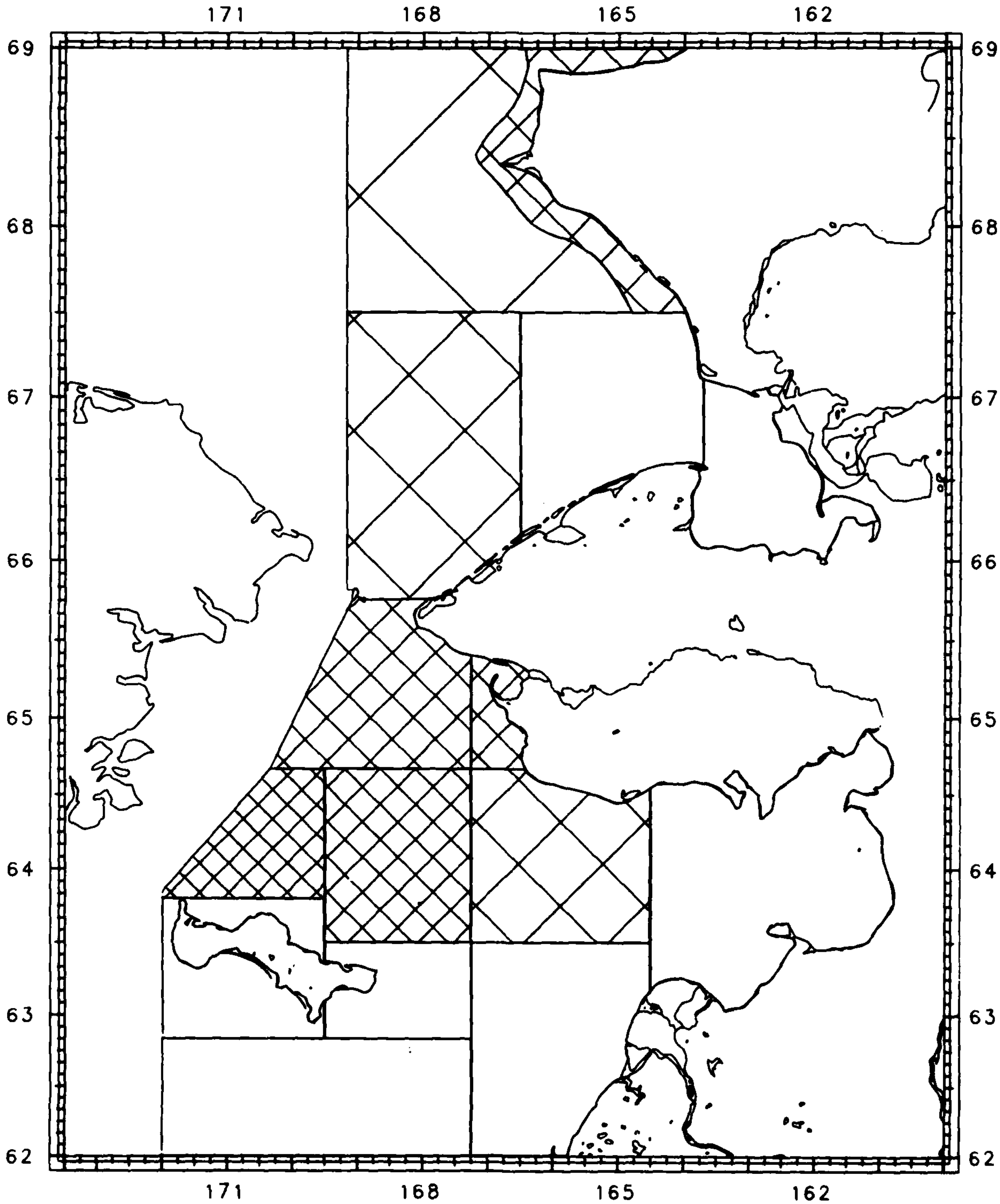

Figure B-34. Shaded regions represent percentages expressed as total number of survey track miles flown divided by the area of each region. Shading varies from all white (representing 0 percent) to all black (representing 150 percent). Data are based on the April-May 1983 Bering and Chukchi Seas aerial surveys. Chukchi Sea region 17 is not shown.

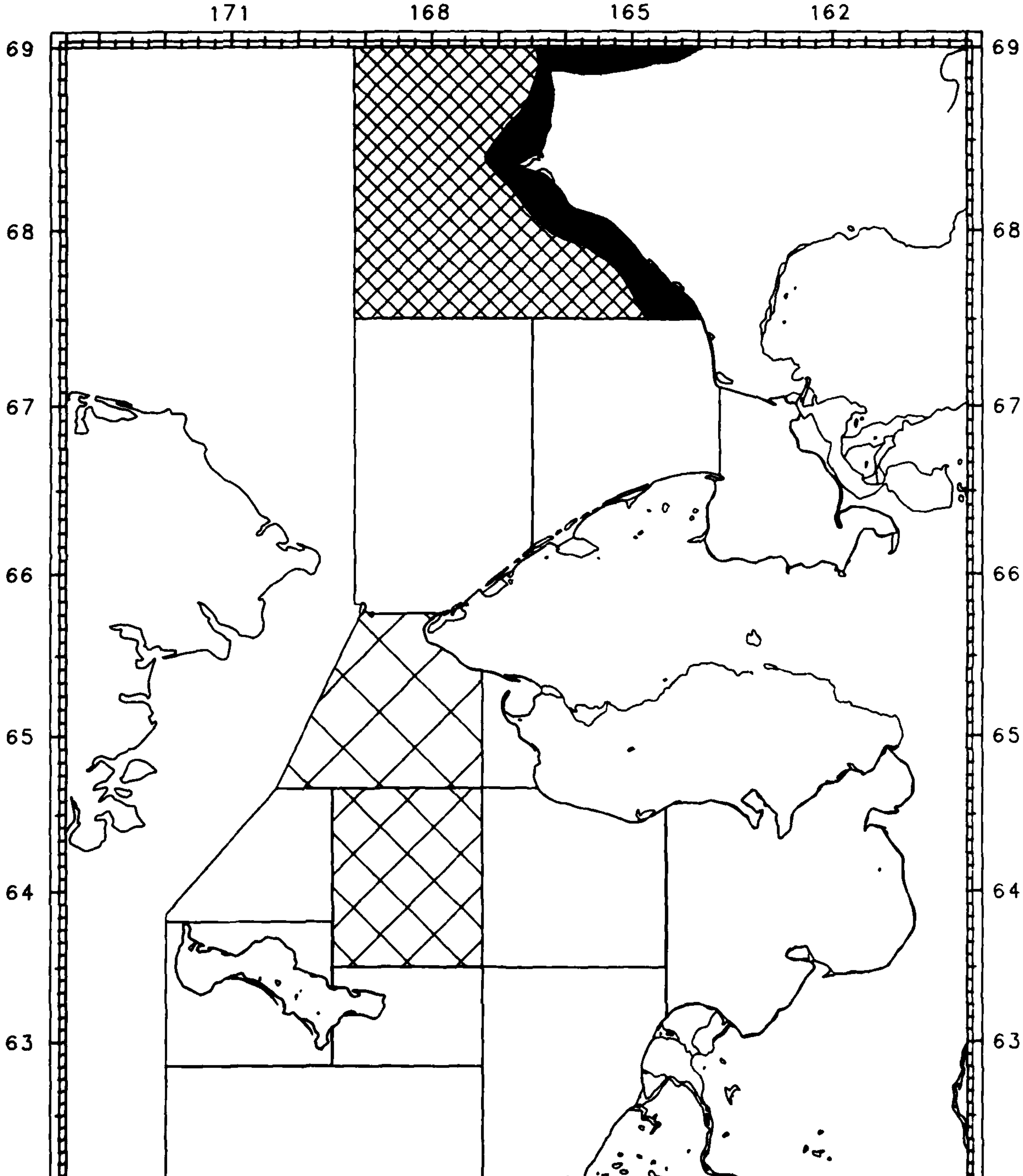

Figure B-35. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Bering and Chukchi Seas during April-May 1983. Shading varies from all white (representing 0 density) to all black (representing 0.2 density). Chukchi Sea region 17 is not shown.

Table B-10. Statistics from aerial surveys of bowhead whales conducted April-May 1979*-1983 in the Bering and Chukchi Seas.

			1980				1981			
Region Name	Region Area nmi^2	Percent of Area Surveyed	Percent of Area Surveyed	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number of Transects Flown (=n)	Number of Bowheads Observed	Density as Number per nmi^2
1	6,542	0.0	0.16	1	0	0.0	0.26	2	0	0.0
2	5,550	0.0	2.68	4	0	0.0	9.18	15	0	0.0
3	2,011	0.0	2.97	3	0	0.0	11.83	8	0	0.0
4	2,211	0.0	3.12	1	0	0.0	25.45	19	0	0.0
5	724	0.0	1.64	1	0	0.0	20.68	4	0	0.0
6	2,313	0.0	2.73	1	0	0.0	49.56	14	828	0.722
7	4,088	0.0	3.27	3	4	0.030	38.68	40	0	0.0
8	4,566	0.0	14.78	15	2	0.003	42.19	55	0	0.0
9	7,262	0.0	4.31	3	0	0.0	12.28	20	0	0.0
10	3,676	0.0	20.24	23	11	0.015	25.77	25	2	0.002
11	767	0.0	35.84	13	2	0.007	39.38	13	0	0.0
12	6,185	0.0	7.57	11	312	0.666	17.33	10	28	0.026
13	4,140	0.0	3.74	3	0	0.0	0.10	1	0	0.0
14	2,469	0.0	0.00				0.00			
15	5,767	0.0	0.35	1	0	0.0	2.22	4	0	0.0
16	1,504	0.0	12.78	5	0	0.0	5.31	4	5	0.063
17	5,096	7.12	16.01	16	49	0.060	10.18	6	18	0.035
			1982				1983			
1	6,542	0.0	0.03	1	0	0.0	0.0			
2	5,550	0.0	1.80	6	0	0.0	0.0			
3	2,011	0.0	9.44	5	0	0.0	0.0			
4	2,211	0.0	14.75	10	1	0.003	0.0			
5	724	0.0	12.86	4	0	0.0	0.0			
6	2,313	0.0	9.12	3	0	0.0	7.15	3	0	0.0
7	4,088	0.0	17.20	20	0	0.0	5.93	6	2	0.008
8	4,566	0.0	12.95	26	0	0.0	2.48	4	0	0.0
9	7,262	0.0	3.19	9	0	0.0	0.0			
10	3,676	0.0	21.46	16	4	0.005	4.83	5	1	0.006
11	767	0.0	32.85	10	0	0.0	5.17	1	0	0.0
12	6,185	0.0	9.58	12	24	0.040	1.89	2	0	0.0
13	4,140	0.0	0.0				0.0			
14	2,469	0.0	0.0				0.0			
15	5,767	0.0	2.48	3	4	0.028	0.81	1	1	0.021
16	1,504	0.0	9.82	3	2	0.014	3.85	3	10	0.173
17	5,096	7.12	15.54	11	7	0.009	9.61	8	11	0.022

*In 1979 surveys were flown only in Region 17. That year 7.12 percent of the area was surveyed, 7 transects were flown, 0 bowheads observed resulting in 0.0 density per nmi^2.

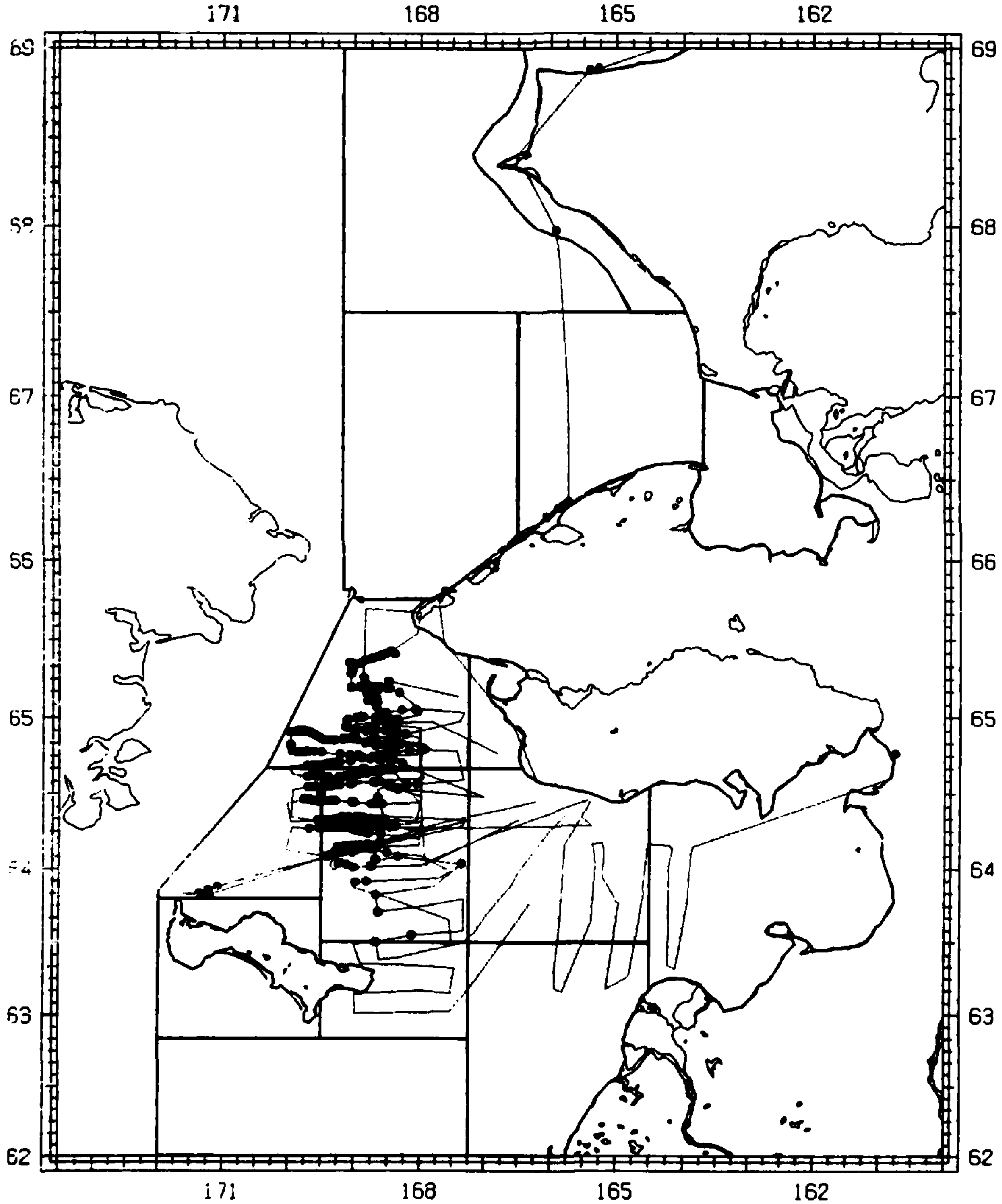

Figure B-36. Plot of aerial survey tracklines flown during July 1983 in the Bering and Chukchi Seas, regions 1–16. Circles represent gray whale sightings.

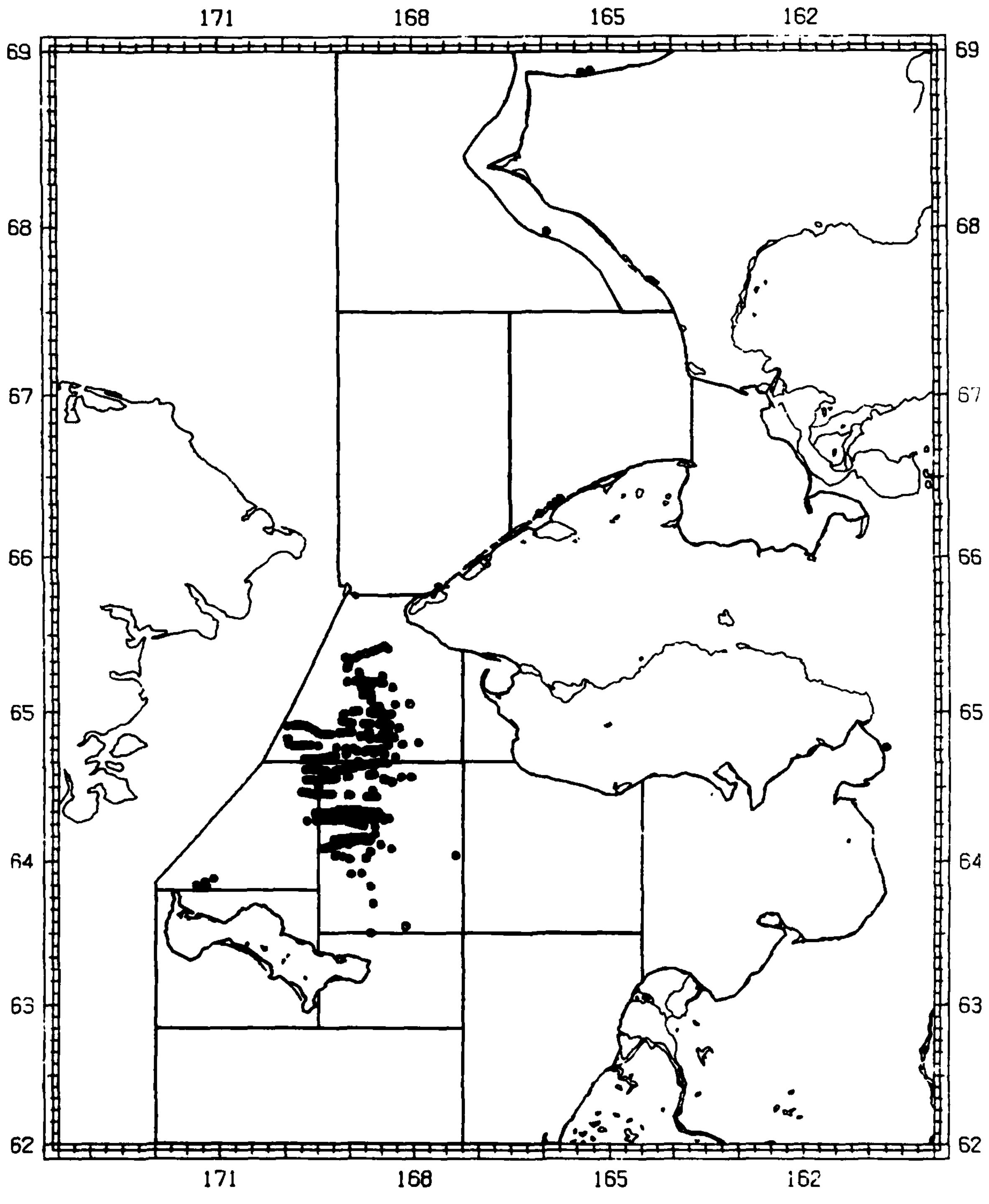

Figure B-37. Plot of gray whale sightings made during the July 1983 aerial survey of the Chukchi and Bering Seas, regions 1-16.

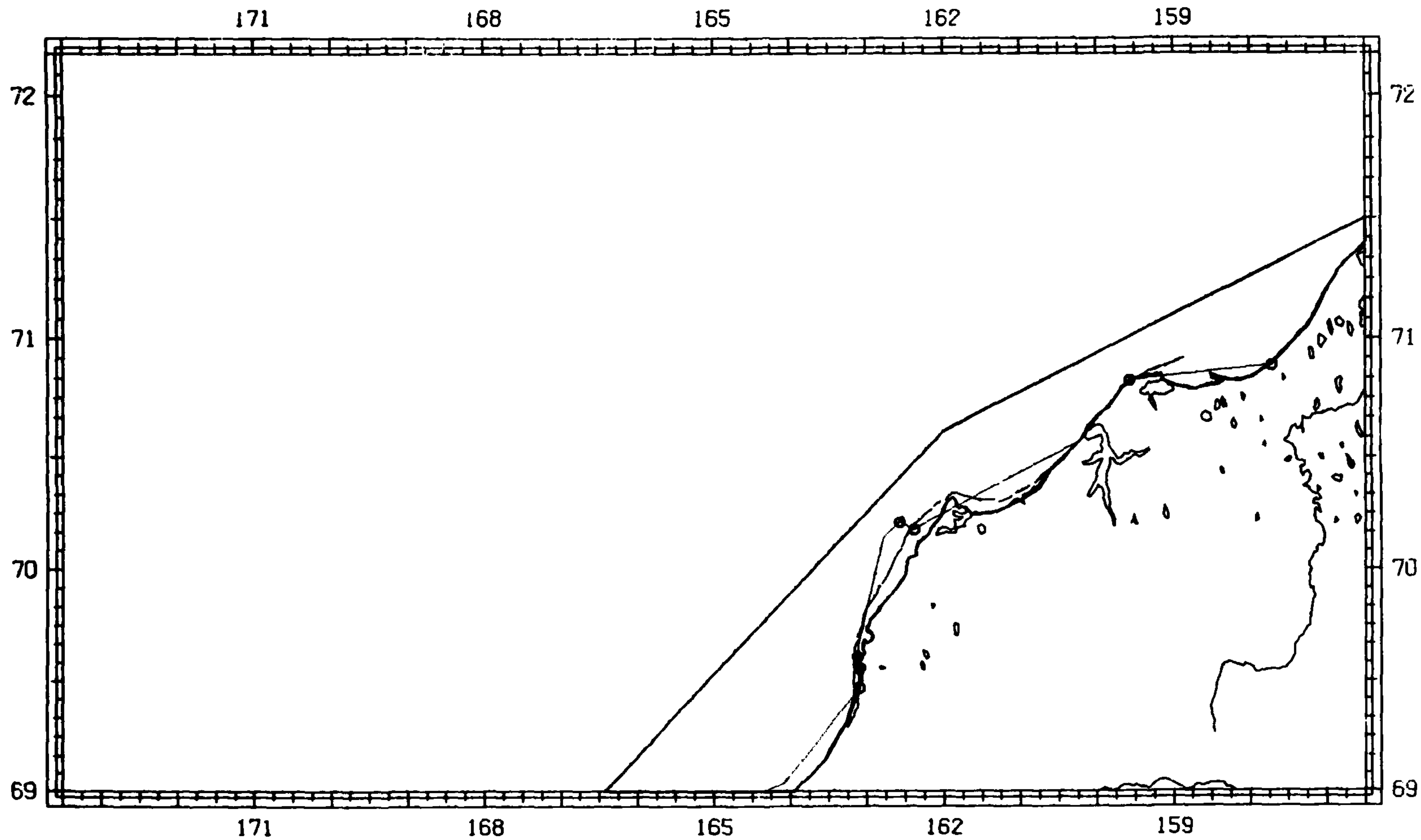

Figure B-38. Plot of aerial survey tracklines flown during July 1983 in the Chukchi Sea, region 17. Circles represent gray whale sightings.

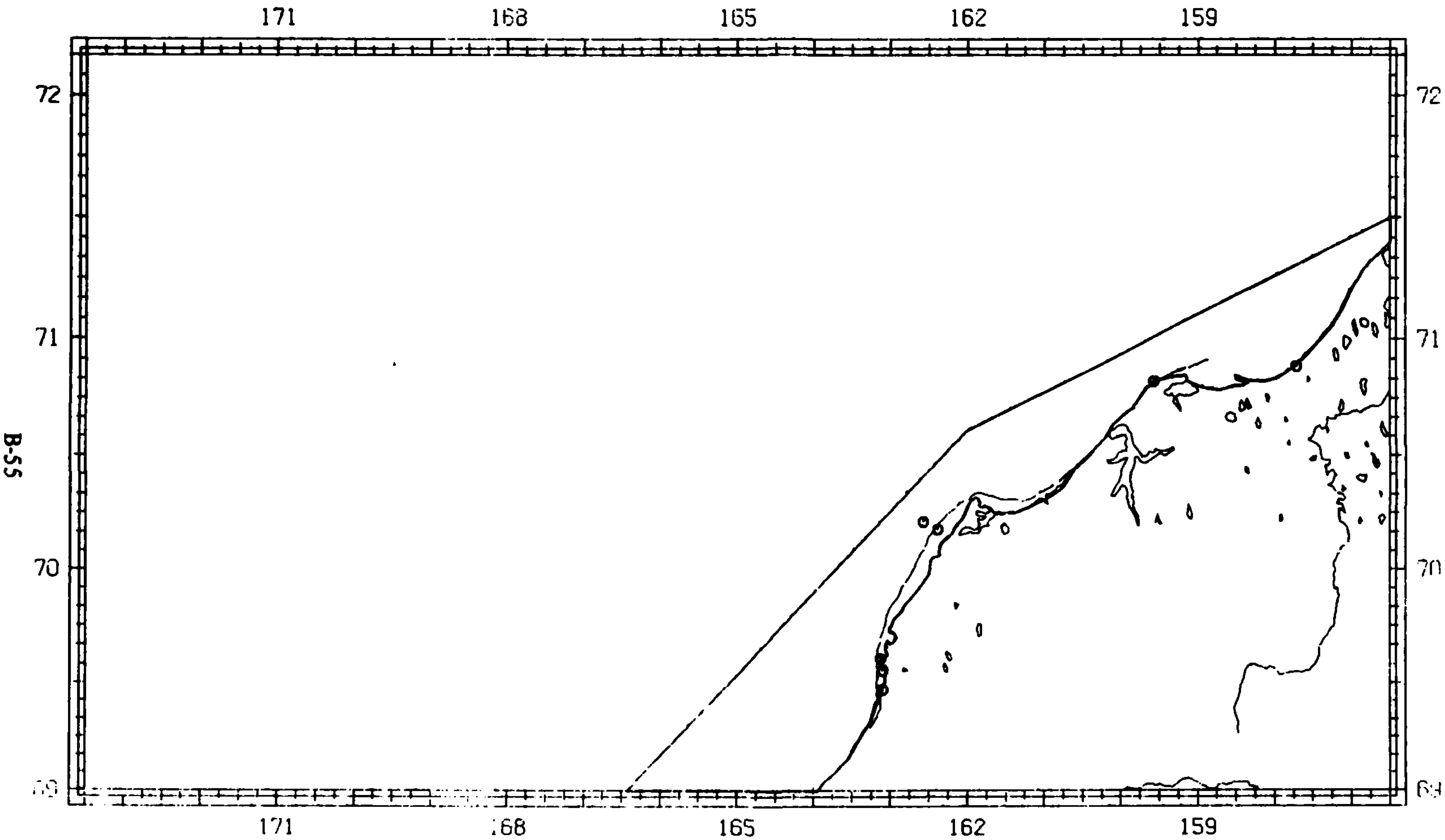

Figure B-39. Plot of gray whale sightings made during the July 1983 aerial survey of the Chukchi Sea, region 17.

Table B-11. Statistics from aerial surveys of gray whales conducted July 1983 in the Bering and Chukchi Seas. Values for each region are summed where appropriate. Region numbers refer to areas depicted in Figure B-28. The total study area was approximately 64,871 nmi^2. Total time spent surveying was approximately 24 hours and 48 minutes.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Grays Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
1	6,542	10.08	0.0							
2	5,550	8.56	1.71	0:40	2.69	7	0	0.0	0.0	0.0 - 0.0
3	2,011	3.10	0.0							
4	2,211	3.41	9.56	1:34	6.32	12	0	0.0	0.0	0.0 - 0.0
5	724	1.12	0.0							
6	2,313	3.56	11.55	1:55	7.73	13	65	0.243	139.8	>0.0 - 0.501
7	4,088	6.30	30.26	8:31	34.35	55	429	0.347	34.5	0.229 - 0.465
8	4,566	7.04	6.76	2:22	9.54	13	0	0.0	0.0	0.0 - 0.0
9	7,262	11.19	2.67	1:18	5.24	7	0	0.0	0.0	0.0 - 0.0
10	3,676	5.67	19.00	5:04	20.43	33	346	0.495	79.9	0.313 - 0.677
11	767	1.18	5.00	0:17	1.14	4	0	0.0	0.0	0.0 - 0.0
12	6,185	9.53	.62	0:17	1.14	1	1	0.026		
13	4,140	6.38	2.24	0:35	2.35	1	4	0.043		
14	2,469	3.81	0.0							
15	5,767	8.89	0.46	0:09	0.60	1	0	0.0		
16	1,504	2.32	3.72	0:25	1.68	3	6	0.107	37.4	>0.0 - 0.370
17	5,096	7.86	3.65	1:41	6.79	12	0			

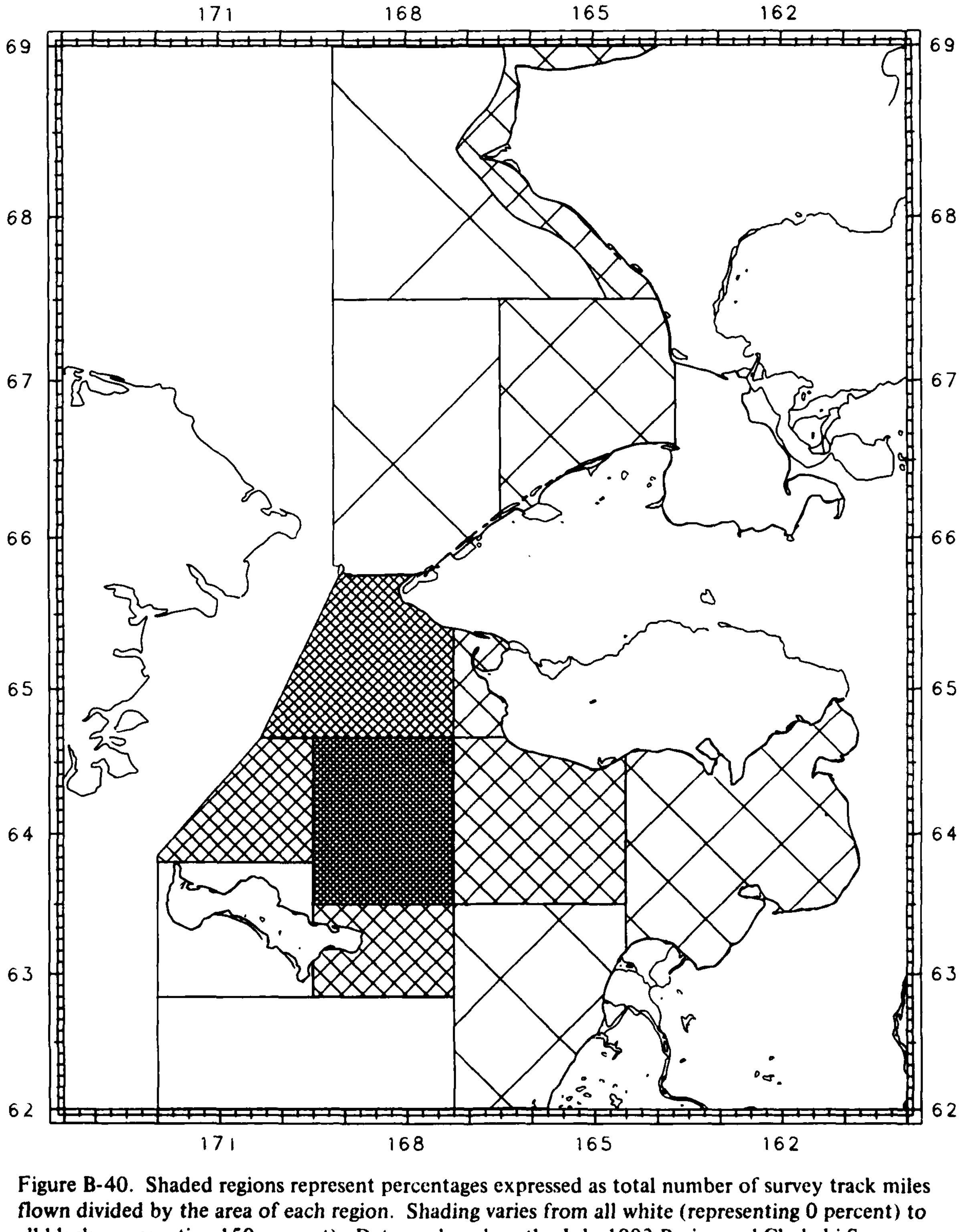

Figure B-40. Shaded regions represent percentages expressed as total number of survey track miles flown divided by the area of each region. Shading varies from all white (representing 0 percent) to all black representing 150 percent). Data are based on the July 1983 Bering and Chukchi Seas aerial surveys. Chukchi Sea region 17 is not shown.

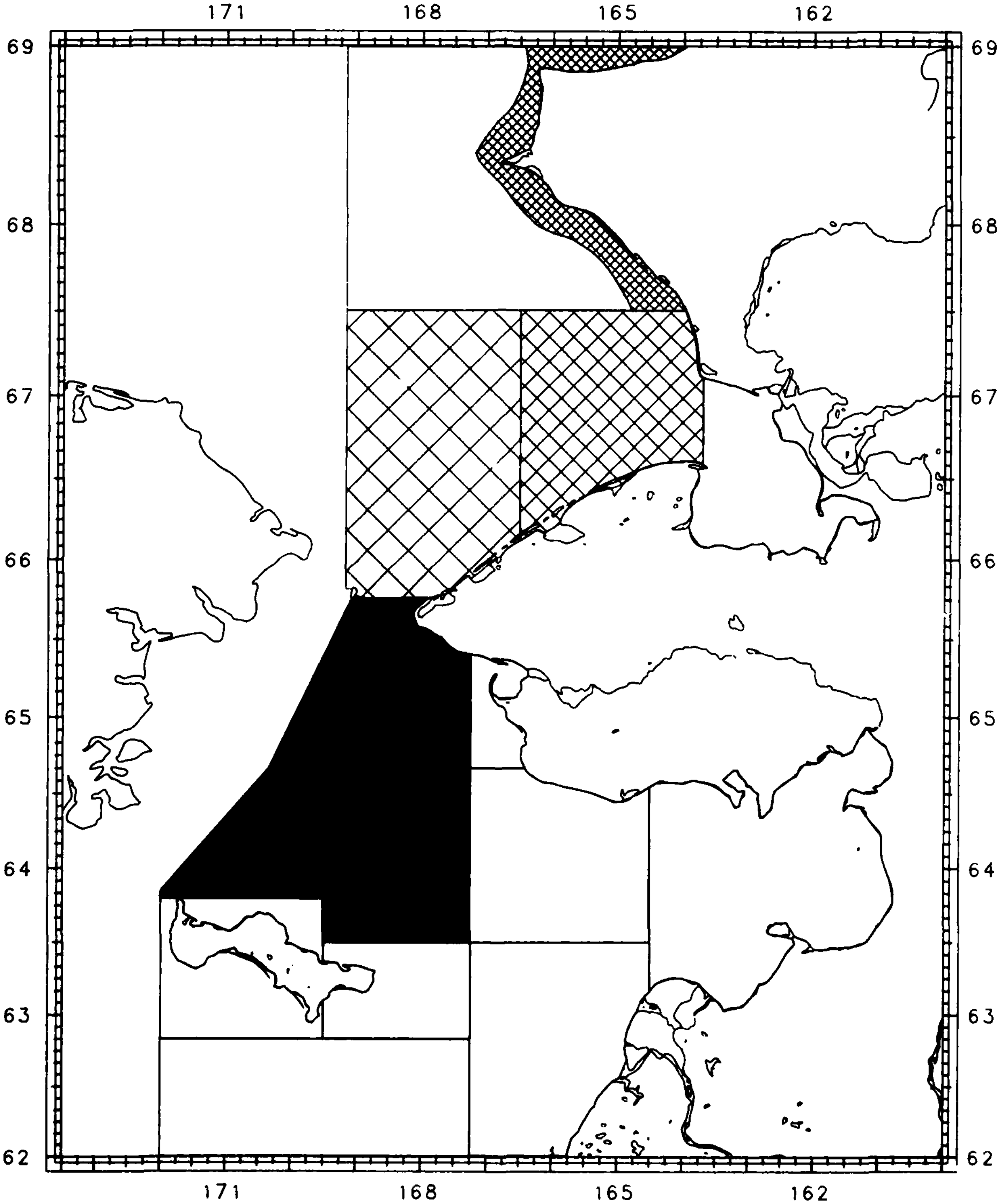

Figure B-41. Shaded regions represent observed densities of gray whales as determined from aerial surveys flown in the Bering and Chukchi Seas during July 1983. Shading varies from all white (representing 0 density) to all black (representing 0.5 density). Chukchi Sea region 17 is not shown.

Table B-12. Statistics from aerial surveys of gray whales conducted July 1980-1983 in the Bering and Chukchi Seas.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Grays Observed	Density as Number per nmi^2	Percent of Area Surveyed	Survey Time HR:MIN	Percent of total Time	Number of Transects Flown (=n)	Number of Grays Observed	Density as Number per nmi^2
			1980						1981					
1	6,542	10.08	0.0						0.0					
2	5,550	8.56	0.0						2.23	1:01	2.53	7	0	0.0
3	2,011	3.10	0.0						0.0					
4	2,211	3.41	0.0						8.20	1:14	3.07	7	0	0.0
5	724	1.12	0.0						0.0					
6	2,313	3.56	0.0						0.0					
7	4,088	6.30	0.0						10.74	3:23	8.42	14	46	0.105
8	4,566	7.04	0.22	0:06	2.03	2	0	0.0	18.21	6:34	16.34	34	0	0.0
9	7,262	11.19	1.39	0:44	14.92	1	0	0.0	7.86	4:44	11.78	26	0	0.0
10	3,676	5.67	1.23	0:29	9.83	2	0	0.0	13.65	4:14	10.54	17	14	0.028
11	767	1.18	3.69	0:13	4.41	1	0	0.0	36.54	2:37	6.51	29	5	0.018
12	6,185	9.53	1.52	0:59	20.00	1	0	0.0	7.09	4:25	10.99	16	9	0.021
13	4,140	6.38	0.46	0:09	3.05	1	0	0.0	10.23	3:03	7.59	18	0	0.0
14	2,469	3.81	0.0						8.29	1:24	3.48	8	0	0.0
15	5,767	8.89	0.50	0:13	4.41	1	0	0.0	4.73	2:15	5.60	7	12	0.044
16	1,504	2.32	3.51	0:44	14.92	3	4	0.076	25.79	3:11	7.92	11	28	0.072
17	5,096	7.86	3.74	1:18	26.44	2	4	0.021	5.02	2:06	5.23	12	21	0.082
			1982						1983					
1	6,542	10.08	0.11	0:04	0.17	1	0	0.0	0.0					
2	5,550	8.56	0.0						1.71	0:40	2.69	7	0	0.0
3	2,011	3.10	1.73	0:14	0.58	2	11	0.317	0.0					
4	2,211	3.41	17.66	3:21	8.30	18	40	0.102	9.56	1:34	6.32	12	0	0.0
5	724	1.12	22.81	1:31	3.76	8	6	0.036	0.0					
6	2,313	3.56	12.18	2:09	5.32	8	7	0.025	11.55	1:55	7.73	13	65	0.243
7	4,088	6.30	30.55	9:55	24.56	48	56	0.045	30.26	8:31	34.35	55	429	0.347
8	4,566	7.04	6.02	2:14	5.53	9	1	0.004	6.76	2:22	9.54	13	0	0.0
9	7,262	11.19	0.0						2.67	1:18	5.24	7	0	0.0
10	3,676	5.67	23.18	6:53	17.04	37	37	0.043	19.00	5:04	20.43	33	346	0.495
11	767	1.18	15.73	1:06	2.72	11	0	0.0	5.00	0:17	1.14	4	0	0.0
12	6,185	9.53	13.85	6:25	15.89	28	5	0.006	.62	0:17	1.14	1	1	0.026
13	4,140	6.38	7.30	2:12	5.45	18	1	0.003	2.24	0:35	2.35	1	4	0.043
14	2,469	3.81	6.05	1:06	2.72	7	0	0.0	0.0					
15	5,767	8.89	0.0						0.46	0:09	0.60	1	0	0.0
16	1,504	2.32	7.75	1:05	2.68	6	24	0.206	3.72	0:25	1.68	3	6	0.107
17	5,096	7.86	3.83	2:08	5.28	5	84	0.430	3.65	1:41	6.79	12	0	

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